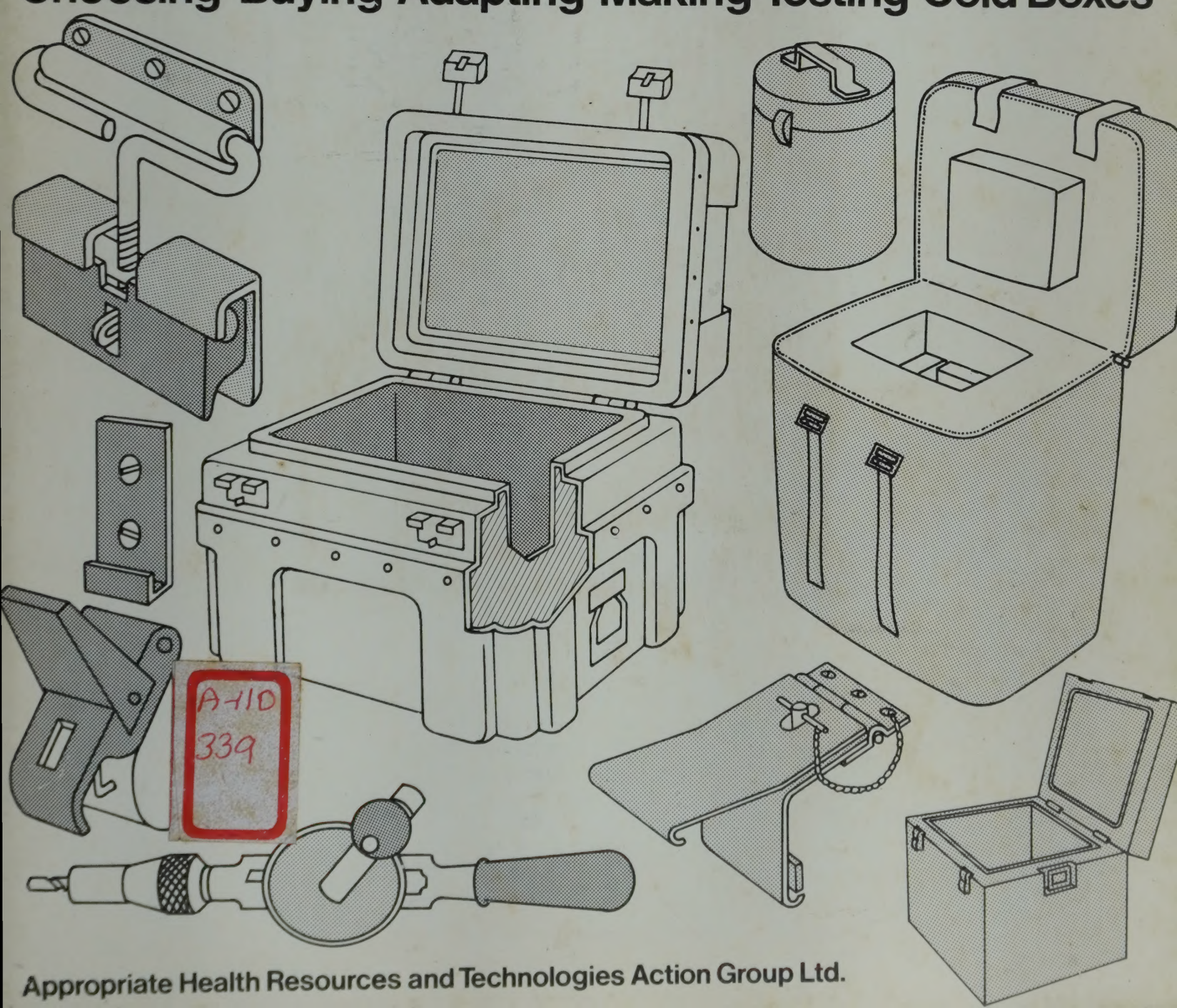
How to choose and make a cold box

Choosing · Buying · Adapting · Making · Testing Cold Boxes



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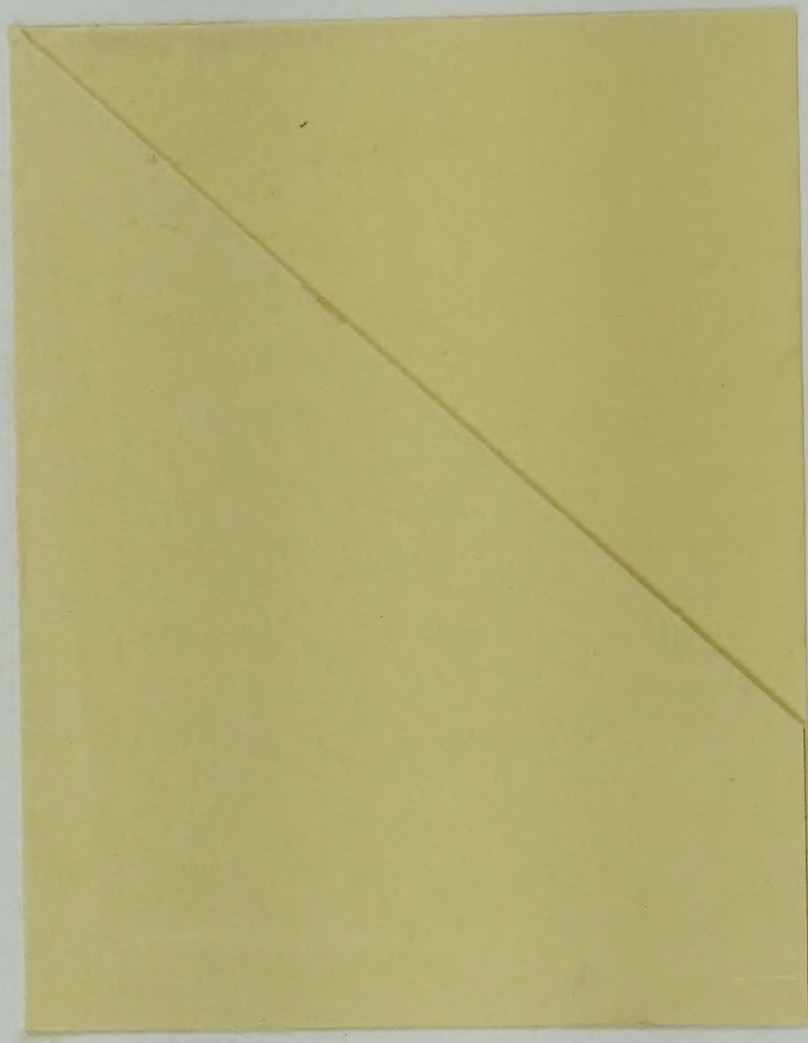

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How to choose and make a cold box

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Foreword

It is well known that controlling common childhood infectious diseases through immunization will drastically reduce child mortality rates in most third world countries.

The task has not yet been accomplished because of the difficulties of reaching children – especially those living in isolated areas. Transport problems, lack of electricity or any power to maintain refrigeration equipment, poor vaccination programmes and lack of quality control for vaccines because of a shortage of information are among the key factors restricting the improvement of immunization coverage.

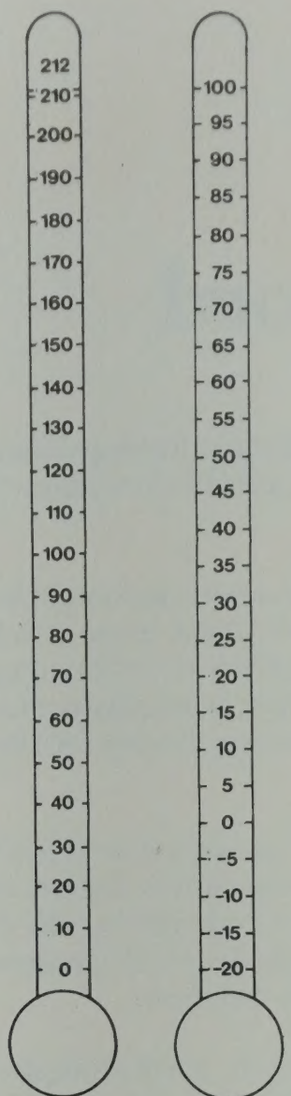
All these problems could be resolved by efficient management of the **cold chain**. Recent field research shows that the cold chain often fails at local level, where vaccines have to be maintained with simple equipment. When this is possible and potent vaccines actually reach children, we can honestly say that we have 'immunized' our population.

This book is a down-to-earth contribution to solving the problem of field level management of the cold chain. Paul Jansdaal and Anthony Battersby present the material in a practical, easy-to-follow format which allows decision-makers and technicians to choose the right kind of cold boxes to preserve and transport vaccines in isolated communities. The information in this book about what type of cold box to choose, buy or make, will help to decrease child mortality, by improving the coverage of immunization programmes.

Jorge A Saravia
Director
Centro de Investigaciones Multidisciplinarias en Desarrollo (CIMDER).
Cali, December 1983

Metric – Imperial conversion

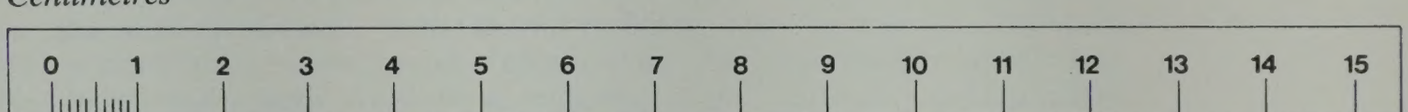
Temperature



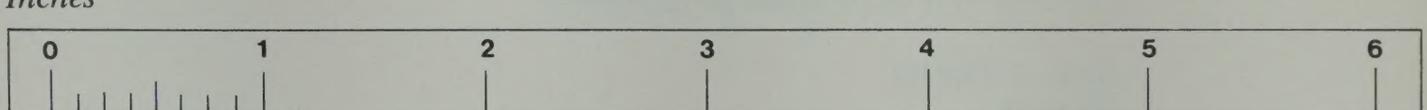
$°C \times 2 - 10\% + 32 = °F$

Length

Centimetres

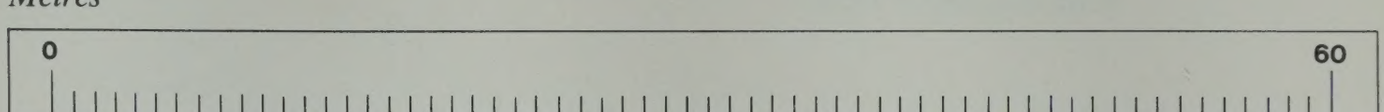


Inches

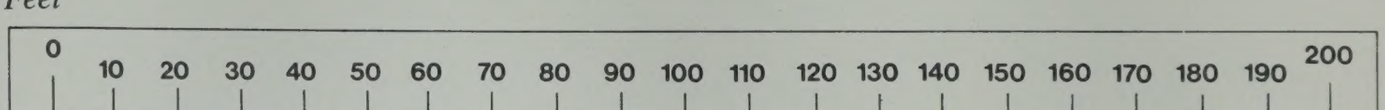


Cms ÷ 2·5 = Inches

Metres



Feet



Length	*Metres ÷ 3 × 10 = Feet*
Area	$M^2 \times 11 = Ft^2$
Volume	*Litres × 2 − 10% = Pints* $Litres \div 30 = Ft^3$
Weight	*Kilograms × 2 + 10% = Pounds (lbs)*

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*There may be technical words in this book that you do not recognise. We have included a list of these on page 68 with explanations.

Introduction

Cold boxes are common in most countries. However only a few of the many different types are safe for storing vaccines. It is your responsibility as an Immunization Programme Manager to choose suitable cold boxes. You may ask a funding agency to supply you, but how will you know what to ask for? You may be able to buy boxes in the local market, but how will you know if they are safe for vaccines? You may ask a local manufacturer to supply you, but how will you know if the manufacturer is making a good cold box? Finally you may decide to make some boxes yourself, but will you know how to do this?

This handbook answers these questions. It is written for Expanded Programme on Immunization (EPI) Programme Managers and those people who are responsible for the supply of cold boxes.

Section 1

The type of cold box* you need

This section helps you to decide:

- the size of the cold box
- the cold life
- the strength
- the cost
- the quantity

There are three types of container for keeping vaccines cold. They all work in the same way. They insulate a space by keeping the heat of the outside atmosphere away from the vaccines. When you put vaccines into them they remain cold. The three types are:

Vaccine flasks

These are very small and hold up to 1 litre. They are kept cold with ice cubes in a plastic bag. They are delicate because the lining is made of glass. You normally only use them to keep vaccine during the immunization session.

Vaccine carriers

These are larger and hold up to 2 litres of vaccine. Unlike the flask they are kept cold by ice packs. Carriers are much stronger than flasks and have a longer cold life. You use them to carry small quantities of vaccine. For example a vaccinator can take one when he goes to an outreach clinic.

Cold boxes

These are the largest containers and hold up to about 30 litres of vaccine. They have the longest cold life. You use them to carry large amounts of vaccine and to store vaccine when your refrigerator breaks down. You can carry small ones by hand, but the larger ones you should carry by vehicle. They are kept cold by ice packs.

Before you can decide what type of cold box you need will have to make the following decision:

- the storage capacity for vaccines you need
- the cold life
- strength
- cost

Also talk to the people who will use the cold box and get their ideas.

** Throughout this book the term cold box is used to include cold boxes, vaccine carriers and vaccine flasks.*

Storage capacity

You must decide how much vaccine you need to store in your cold box. To help you, use the following formula.

$$\frac{\text{Total number new births p.a.} \times 3}{100} \div \text{Number of supply periods p.a.} = \text{Net volume of cold box in litres.}$$

This formula is based on the following table:

Target group	*Vaccines (doses/ vial)*	*Target immuniza-tions in one year*	*No. of doses*	*Cm^3 per dose including packaging*	*Wastage multi-plier*	*Convert cm^3 to litres*	*Net vaccine require-ment litres*
Infants	BCG (20)	35 000	× 1	× 1.0	× 2.0	÷ 1 000 =	70
	DPT (20)	35 000	× 3	× 2.5	× 1.3	÷ 1 000 =	341
	Measles (10)	35 000	× 1	× 3.0	× 1.3	÷ 1 000 =	136
	Polio (20)	35 000	× 3	× 1.5	× 1.3	÷ 1 000 =	205
		Total requirement for infants:					752
School children	DT (20)	26 000	× 1	× 2.5	× 1.3	÷ 1 000 =	84
	BCG (20)	26 000	× 1	× 1.0	× 2.0	÷ 1 000 =	52
		Total requirement for school children:					136
Mothers	Tetanus (20)	35 000	× 2	× 2.5	× 1.3	÷ 1 000 =	227
Total net vaccine storage requirement per year in litres for all groups							1115

The table is based on the following:

Population – 100,000

Birth rate – 35 per 1,000 population

School entry – 75% of new births

All mothers are given tetanus toxoid

Coverage – 100%

Note: The volume of vaccine in its packaging varies from one manufacturer to another. So check the volumes of the vaccine which you use.

Example:

1. Decide the size of a cold box to supply a store in a district with 700 new births a year. The store is supplied quarterly.

$\frac{700 \times 3}{100} \div 4 = 5.25$ litres. Therefore you need a cold box with a net volume of 6 litres.

2. Decide the size of the cold boxes to supply vaccine in a region with 6 districts and 35,000 new births a year. The districts are supplied quarterly.

$\frac{35{,}000 \times 3}{100} \div 6 \div 4 = 43.75$ litres per district.

This calculation shows you the total storage space you need for your vaccines. To this you will have to add the space taken by the ice packs. You will then need to decide how many boxes you require (see page 5).

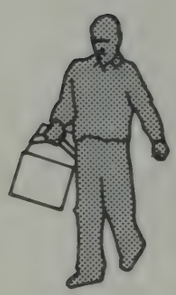
Cold life

To decide this find out the journey time from the supplying store to the furthest supply point. Double this and you have the cold life which the box must have. If the journey times to different stores vary a lot, you may be able to have different types of cold boxes.

Example:
Journey time from a regional store to a district store is two days. The cold life is therefore four days. This allows for any delays that arise.

Method of transport

There are many ways to transport your vaccines. Some are shown in the following illustration:

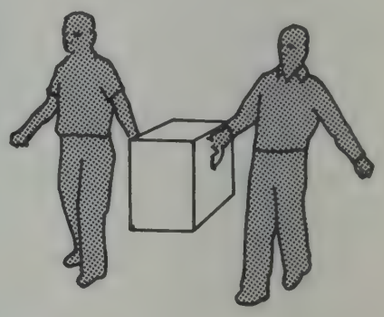


5 kg – 1½ to 2 km

10 kg – to 5 km

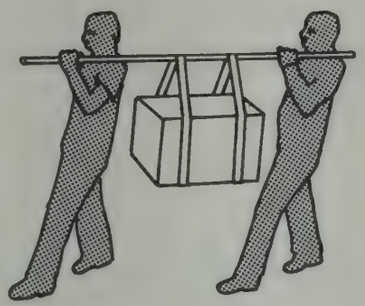
15 kg – 5 to 10 km

20 kg – 1½ to 2 km

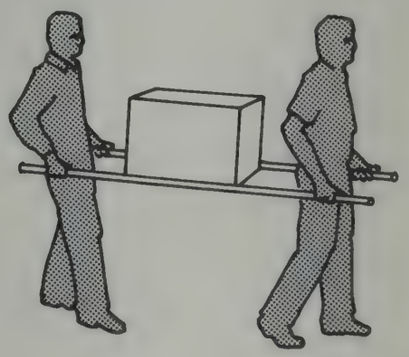


30 kg – 1 to 2 km

20 kg (10 + 10) – 5 km

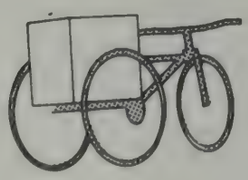


20 kg – 10 km

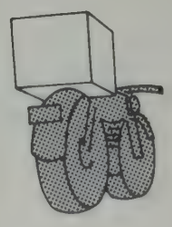


30 kg – 5 km *60 kg – 2 km*

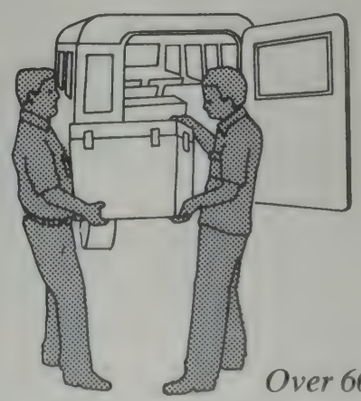
Over 40 kg



Over 40 kg



Over 40 kg



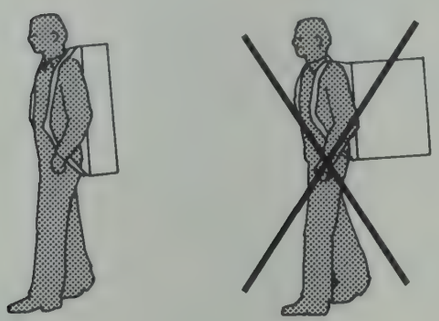
Over 60 kg

The method of transport also influences the size and shape of the cold box. A litre of vaccine in a cold box will weigh between 1.5 kg and 2.5 kg depending on the overall size of the cold box. The smaller the box the greater the weight per litre.

Example:
You have to take 50 litres of vaccine once a quarter from your regional store to a district store, a distance of 5 km.
50 litres weight between 75 kg–125 kg. If there is a vehicle, you could use two 25 litre cold boxes. However if you have to carry the vaccine you need 4–6 10 litre cold boxes.

There are two other important points to remember:

- The cold box must fit the space available in your vehicle.
- A cold box which you carry should keep most of the weight as near the body as possible.



You will find it easier to carry a cold box if it is fixed to a carrying frame made of bamboo, tubular metal or wood.

Strength

Some cold boxes are stronger than others (see Table in Annex II). All the cold boxes listed have been tested for strength. This is rated from 1–5, 1 is the weakest and 5 the strongest.

You must decide how strong the box needs to be. If you need a very strong box your choice is more limited.

Cost

As you can see from Annex II the cost of cold boxes varies a lot. Usually you will choose the cheapest box that satisfies the needs of your programme.

However, a more expensive box may be suitable for the following reasons:

- there is a locally made box. So there is no need to use foreign exchange.
- the donated funds are for a particular make.
- the box is a part of a larger order, which overall is the best price.
- you will not have the money again, so it is worth paying more for greater durability.

Quantity

Once you decide the size and type of cold box then work out how many of each type you need.

You probably need a cold box for:

- each health centre (5–20 litres)
- each outreach worker (0.5–2 litres)
- each mobile team (10–20 litres)

and several cold boxes at district and regional stores (20–30 litres). Remember a cold box only keeps cold when it is lined with ice packs. These you must keep frozen.

Make sure all centres have enough freezing capacity to provide the necessary frozen ice packs.

Example:
There are three outreach workers at a centre. Each has an outreach clinic every day. You probably supply each with a 2 litre vaccine carrier which needs 1.5 litres of ice packs. Therefore, your freezing capacity in 24 hours must be $1.5 \times 3 = 4.5$ litres. If you choose your refrigerator from the UNICEF Product Information Sheets (SUPDIR), you will find the freezing capacity there. If you are buying a refrigerator, make sure you know its freezing capacity is adequate.

Section 2

Buying a cold box

This section tells you about the different materials that are used to make cold boxes. It also gives you a check list to use when you buy a cold box.

You may buy cold boxes locally or from abroad – possibly with funds provided by an aid agency. In either case, make sure that the box meets your needs.

The 26 boxes listed in Annex II have all been tested and are suitable for carrying vaccines. You may be able to buy them in your country, or directly from the manufacturer, or through a funding agency.

When you are buying one of these boxes, check:

Storage capacity: is this sufficient for your needs?

Cold life: if the ambient temperatures are lower than 43°C in your country, the cold life will be longer. To find out the cold life at 32°C, multiply the stated cold life by 1.3.

Weight: is the loaded weight within the limits of the type of transport you have?

Durability: is it strong enough?

Ice packs: if these are not included make sure you have enough and that they will fit into the box. You should have double the quantity needed to fill the cold box so that you can always keep some in the freezer.

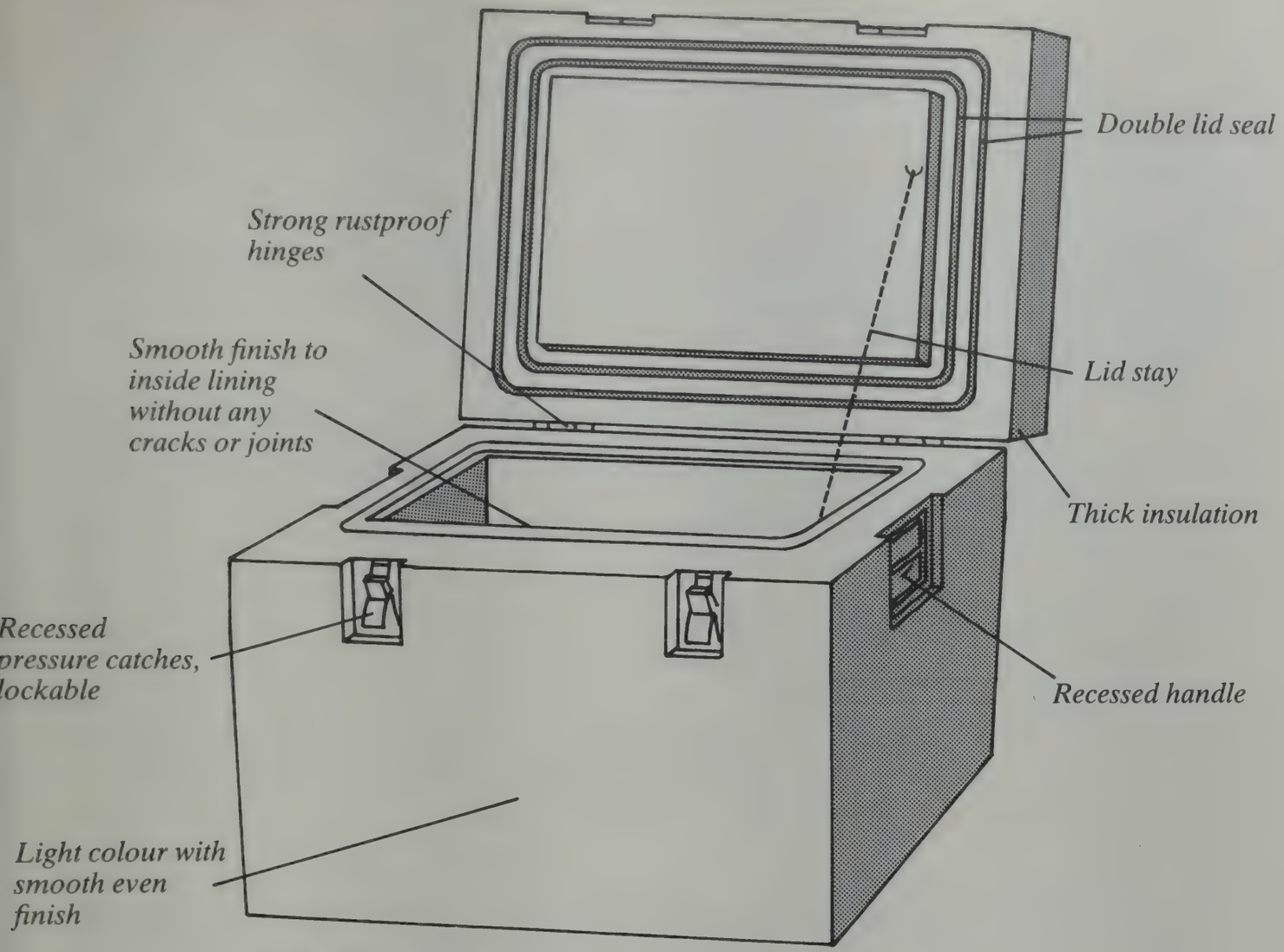
Kilograms of ice packs: make sure your freezing equipment can freeze the necessary weight* of ice packs.

Price: these prices are only for comparison. You must find out the real price before you give your order.

Name: make sure you give the exact name and model.

Size: will the cold box fit the space you have in your vehicle or is it suitable to be carried?

*1 litre of ice = 1 Kilogram.



A good cold box

If you decide to buy a locally made cold box which is untested, check:

Construction materials

A cold box may be made of plastic, metal, fabric, leather or wood.

Plastic

There are many forms of plastic. Some are much better than others. The best material is called polyethylene. It is very strong and weatherproof.

Another suitable material is fibre glass reinforced polyester, usually called FRP or GRP. This material has many advantages for local manufacture.

You use these two plastic materials for the outer shell of a cold box.

Think very carefully before you buy a box made of another plastic, such as styrene. Sunlight destroys them quickly. They may however be used for the lining.

Metal

Cold boxes can be made from steel, aluminium or stainless steel. Steel must be protected from rust by being painted, zinc coated or cadmium coated. Zinc plating leaves a grey crystallized finish. This must be done after all welding is complete. Cadmium plating gives a yellowish finish.

Fabric and leather

The outside of a cold box may be made of fabric or leather. These can form a strong, robust, light and long-lasting finish. If they are used inside the box a waterproof layer must protect them.

Wood

This is often a common material. Marine quality 12–15 mm plywood especially produces a strong box. It must be painted white. In many countries wood needs treatment to prevent damage from termites. Moisture and termite proofing should be done by vacuum impregnation. Painting alone is not adequate. Wood is easy to use, but may be much heavier than other materials.

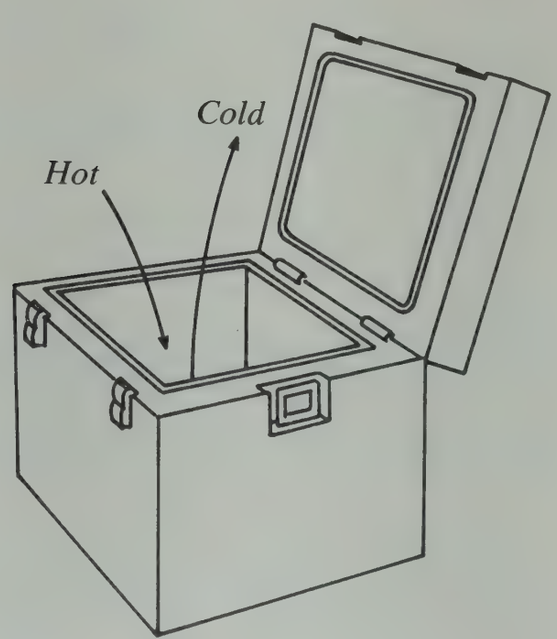
Insulation

How insulation works

The insulation keeps the heat of the outside atmosphere away from the vaccines and keeps the cold from the ice packs inside.
Heat travels from one place to another in three ways:

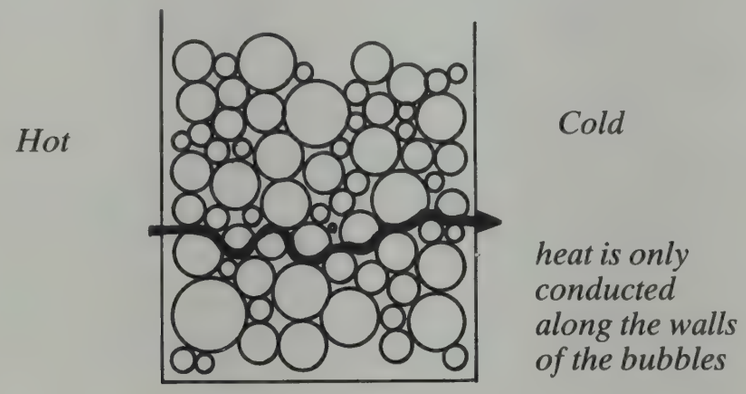
○ Convection

If it is able to move, air will carry heat or cold from one place to another. For example if the lid of a cold box does not fit well, air will be able to move and will allow warm air to flow in and cool air to flow out.



○ Conduction

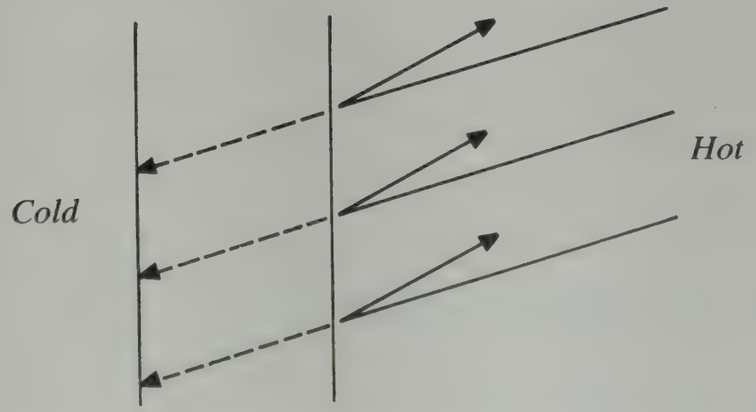
(Heat transfer within a material from cold to warm and warm to cold).
The denser a material is, the better it can conduct heat. So air is a bad conductor and a steel bar a good conductor.
So that there is the least possible conduction, you need as little density as possible in the space between the hot side and the cold side. In a vacuum flask all the air has been removed so there is no density at all, and no heat can cross the gap by conduction. But this is not a very practical solution for a large container. A better solution is to trap a gas of very low density in small particles so that it cannot move. This is what polyurethane foam does. Inside each bubble of foam is a tiny bit of freon gas, which is less dense than air. It is in a sealed bubble and so cannot move. Therefore there is very little heat conduction.



○ Radiation

For radiation to work there must be a transmitter of heat (the sun) and a receiver of heat (the cold box). When the rays of the sun touch anything, it reflects some of the light away from itself. It takes in the rest as heat. Dark coloured objects reflect much less light than light coloured objects (that is why they are dark). Therefore they take in more heat. Cold will also radiate like heat, and this will take cold out of the box.
The more light a surface reflects, the less light it takes in and so the less heat it creates.

Ideally a cold box should have a mirrored surface, like a vacuum flask. This is often not practical. But a smooth white surface works well.



The insulation must lessen heat movement by these three means:–

● An air tight seal to the lid to the cold box lessens convection. The space between the inner and outer shell must be completely sealed. And it must have no large gaps to allow air movement.

- A very low density material in the space between the shells lessens conduction.
- Smooth and light-coloured surfaces lessen radiation of both heat and cold. They reflect as much light as possible.

The best materials are:

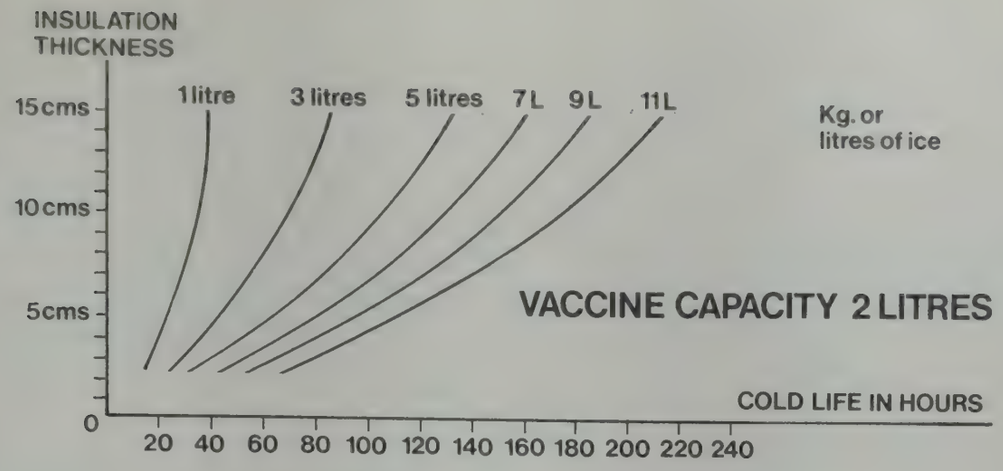
- polyurethane foam – this is a yellowish brown colour. It has a closed cell structure so air does not pass through it.
- polystyrene closed cell foam – this is bluish-white in colour.
- polystyrene open cell foam – often called 'Styrofoam' or 'Thermocole'. It is white and comes in sheet, granules or pellets. It is common all over the world because it is used as a packing material.
- glass fibre wool and rockwool can also be used.
- cork slab is not as good as the above materials, but you can use it if you have nothing else.

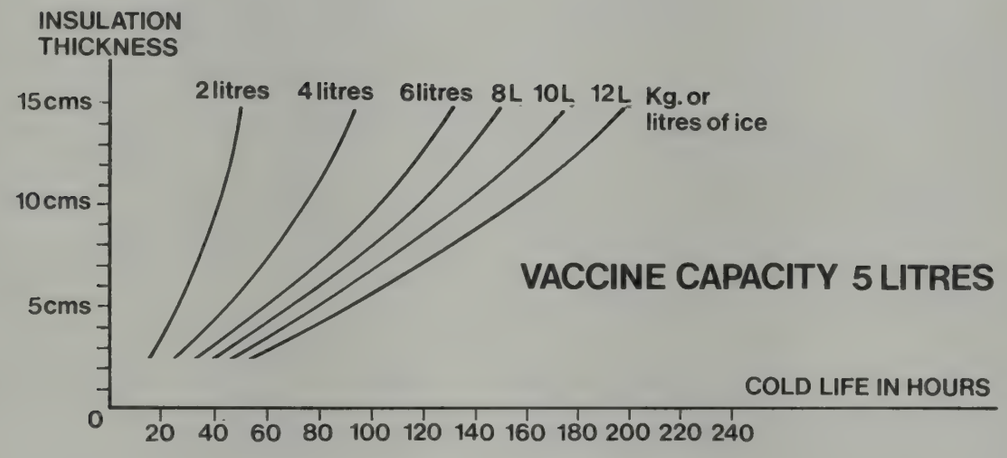
Insulation must be thick enough. Check the insulation in an existing cold box. If there is not enough insulation you will have to use more ice packs. This reduces the usable space and increases the weight. Make sure that the insulation goes all the way round the box. Often the lid has less insulation than the rest of the box. And sometimes there are gaps in the foam lining. If the box is made of plastic, check to make sure that the insulation fills all the space available. If it does not, you will notice either unevenness on the surface, or you will feel soft spots when you press the surface.

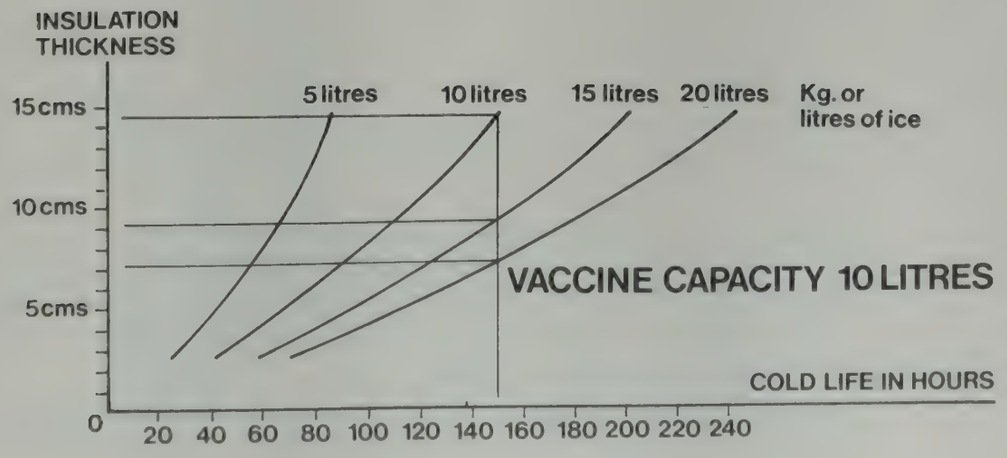
Thickness of the insulation

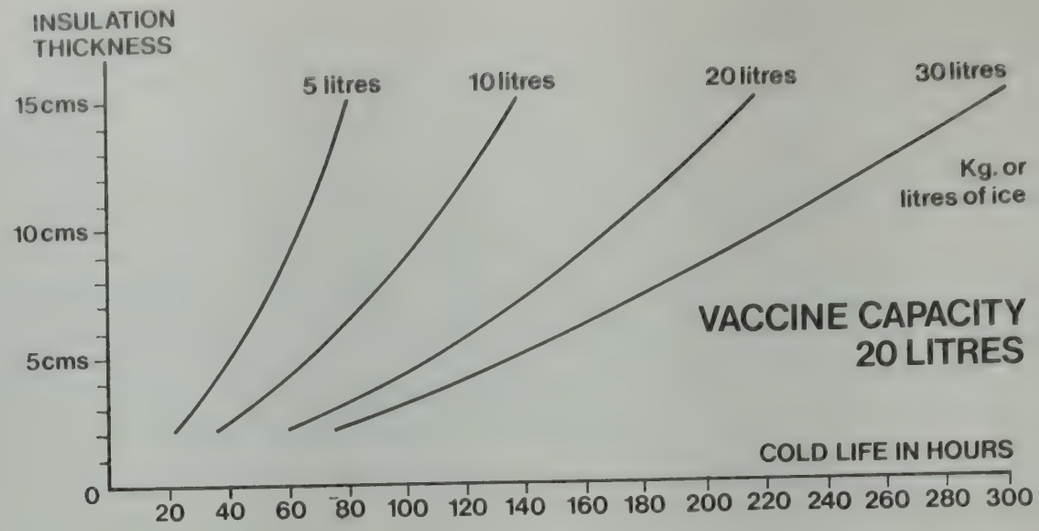
This depends on many points, but the following graphs are a useful guide.
The formula for preparing these graphs is in Annex IV.
The graphs are based on the following:
The cold box is a cube. For practical purposes it has the smallest surface area in relation to its volume.
The insulation is polyurethane foam.
There is not heat loss through the lid and lid seal.
There is 30% space between the ice packs. The outside (ambient) temperature is 43°C.

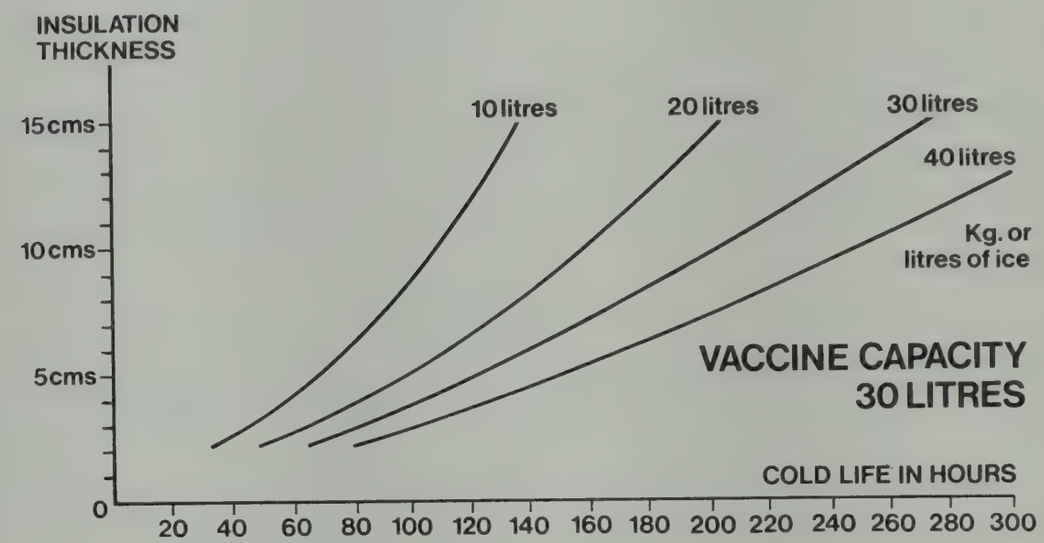
To find the cold life at 32°C ambient temperature multiply the answer by 1.3.
The graphs are for five (5) sizes of cold box. They show the relationship between the cold life, volumes of ice packs and the thickness of insulation. For each cold life you have a number of choices, from a lot of ice packs and a little insulation, to a lot of insulation and few ice packs.
You must decide which combination suits you best.


INSULATION THICKNESS
15cms
10cms
5cms
0
1 litre
3 litres
5 litres
7L
9L
11L
Kg. or litres of ice
VACCINE CAPACITY 2 LITRES
COLD LIFE IN HOURS
20 40 60 80 100 120 140 160 180 200 220 240


INSULATION THICKNESS
15cms
10cms
5cms
0
2 litres
4 litres
6 litres
8L
10L
12L
Kg. or litres of ice
VACCINE CAPACITY 5 LITRES
COLD LIFE IN HOURS
20 40 60 80 100 120 140 160 180 200 220 240


INSULATION THICKNESS
15cms
10cms
5cms
0
5 litres
10 litres
15 litres
20 litres
Kg. or litres of ice
VACCINE CAPACITY 10 LITRES
COLD LIFE IN HOURS
20 40 60 80 100 120 140 160 180 200 220 240





Example:

You need to decide how thick the insulation will be for a 10 litre cold box with a 150 hour cold life.
The 10 litre graph gives you a choice:

14.5 cms insulation and 10 litres of ice packs

or 9.5 cms insulation and 15 litres of ice packs

or 7.5 cms insulation and 20 litres of ice packs.
The first gives a large fairly light box and the third a small heavy one. You need to decide according to your needs (see Section 1).

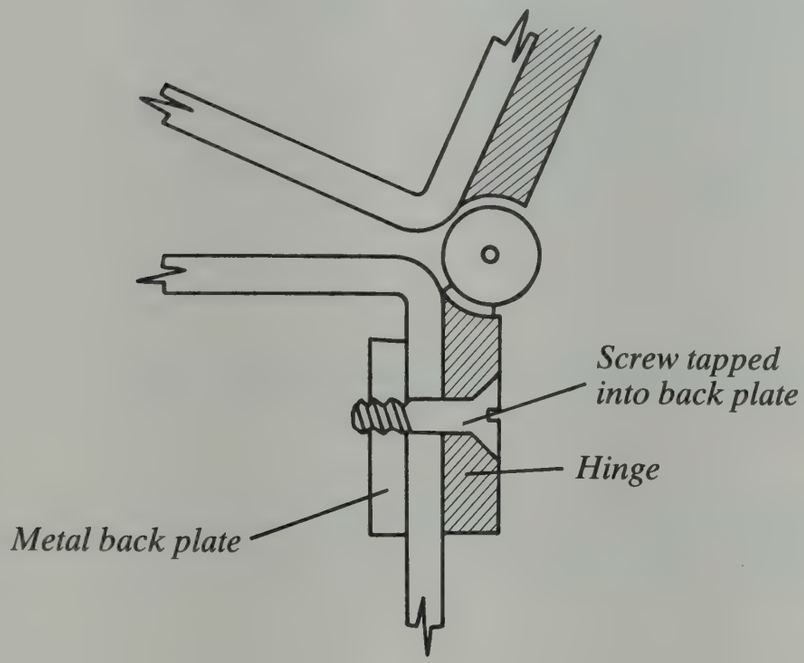
The various types of insulation are described on pages 44 and 45.
They are available in sheets, or granules, or fibres, or as liquids. If you use a liquid you must mix it and pour it into the space where it foams through chemical action. You sometimes use a foam injection machine for this. But you can mix the chemicals by hand and pour them into the cavity.
All insulation takes in water and this makes it much less effective. This is why you need to make good water-vapour proof joints on a cold box.

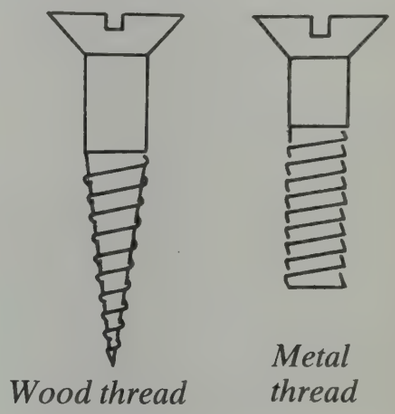
Accessories

The best material for accessories is stainless steel or brass.

Hinges

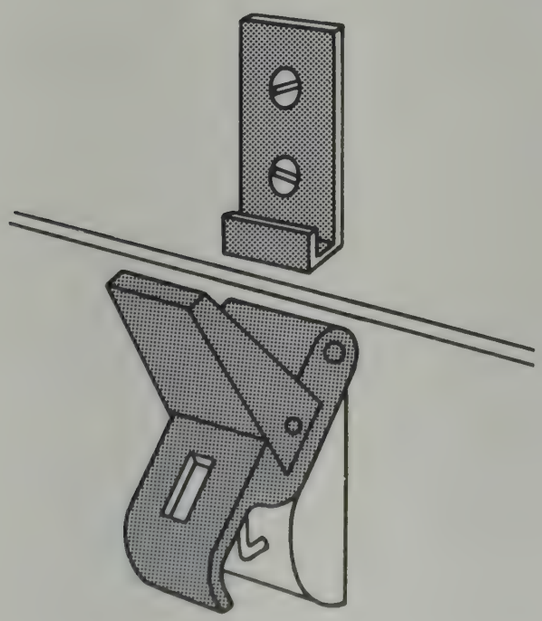
Wooden boxes often use a continuous piano hinge. But with other boxes a pair of strong steel or brass hinges is necessary. If the box is plastic, check that the hinges have a metal back plate. Remove one screw. If it has a metal thread the back plate is metal.





Catches

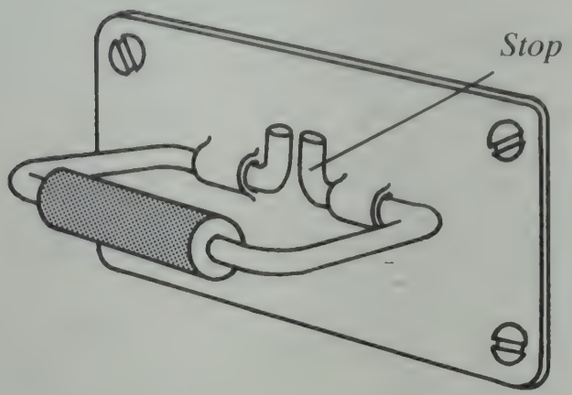
The closing catches on a box should be strong and if possible lockable. The best catches are adjustable or sprung, so that the lid is held down with pressure.



Pressure catch

Handles

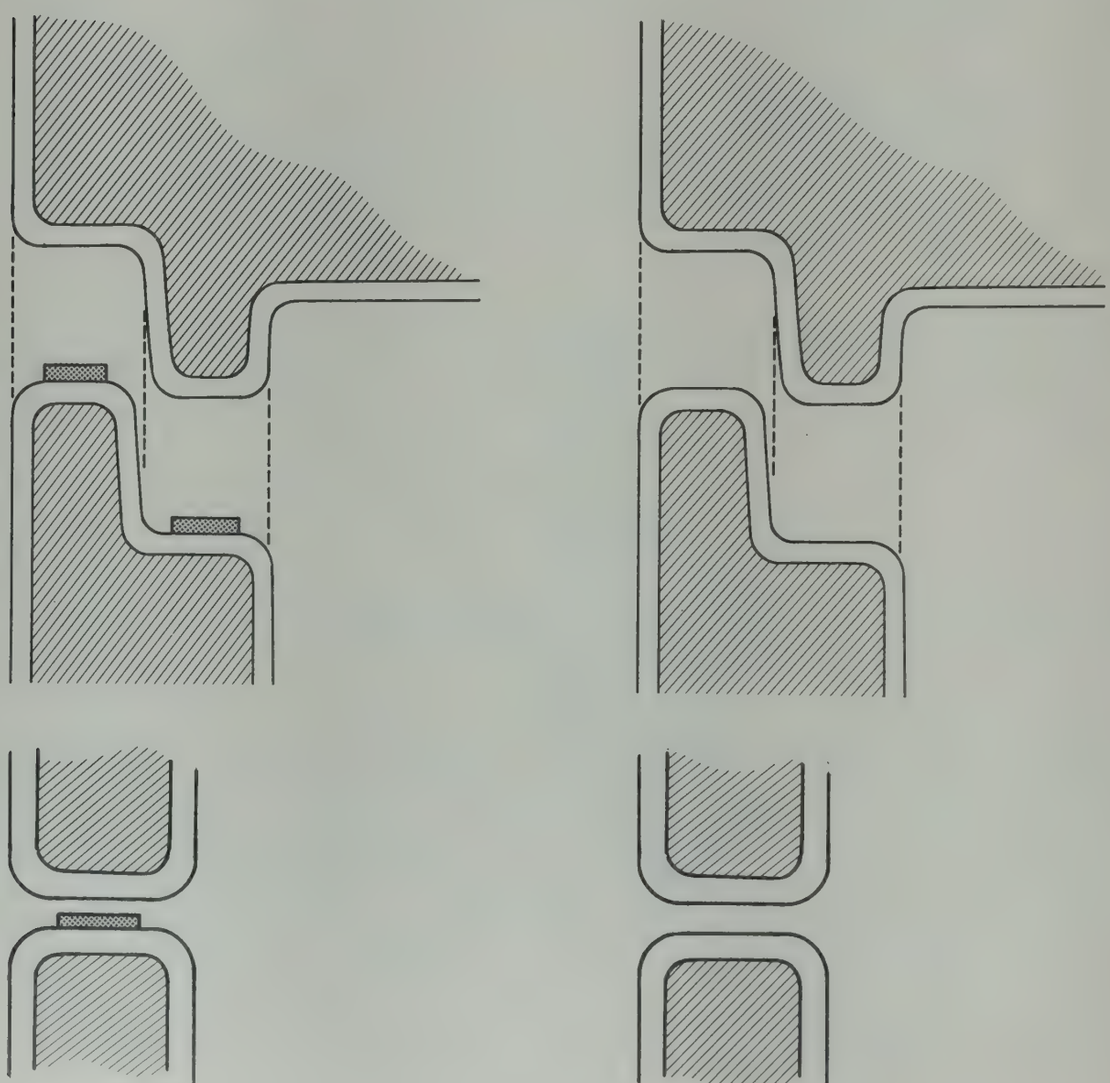
Handles can be mounted into the outer shell of a plastic cold box or screwed on. If they are screwed on, they should have a back plate like the hinges. A stop to prevent the handle lifting above the horizontal is also necessary.



The handle must be above the centre of gravity of the box when you load it fully. Otherwise it will turn over when you pick it up.

Lid seal

This is most important. A good seal between the lid and box is essential. There are several ways to do this (see pages 18, and 55–56).



Rubber can be used, but it tends to dry out and crack. A better material is neoprene, but it costs more than rubber. A profiled plastic lid with a tight fit gives a good seal.

Lid stays

A lid with a hinge must have a stay. With this there is no strain on the hinge, when you open the lid (see page 13).

Finishes

Make sure that the outside is white to reflect heat and that the inside is smooth and even. This helps to keep the box cool. There must be no cracks in the box. And if it is made in sections, the joints must be well sealed. Cracks allow moisture to reach the insulation and this makes it less effective.
There should be no bolts passing right through the insulation, they act as a heat bridge. They therefore bring heat into the box.

Durability and availability

If you find a cold box that you think is suitable, get a sample. Then test it to see if it suits your needs. This test is described in section 7. Also show the box to the people who are going to use it and get their comments. Check with the supplier that the cold box is easy to buy and that you can buy spare parts such as lid seals.

Buyer's check list

The following check list summarizes the main points you should look for when buying a cold box. The answers to all these questions should be **yes**.

		Yes	No
Construction materials			
Plastic	– Polyethylene or GRP?		
Metal	– is steel fully rust proof?		
Fabric or leather	– is inside waterproof?		
Wood	– is it vacuum impregnated and waterproof?		
Insulation			
● polyurethane			
● is insulation thick enough?			
● is insulation complete (i.e no gaps)?			
● is lid well insulated?			
Accessories			
● are they protected from rust?			
● are they firmly fixed with a back plate?			
● are catches lockable?			
● are catches adjustable?			
● do handles have stops?			
● are handles above centre of gravity?			
Lid seal			
● is lid seal good?			
Lid stay			
● is there a lid stay?			
Finishes			
● are the inside and outside of the box white?			
Durability and availability			
● is it strong enough?			
● are spare lid seals available?			
● are ice packs included?			

Section 3

Changes you can make to a cold box

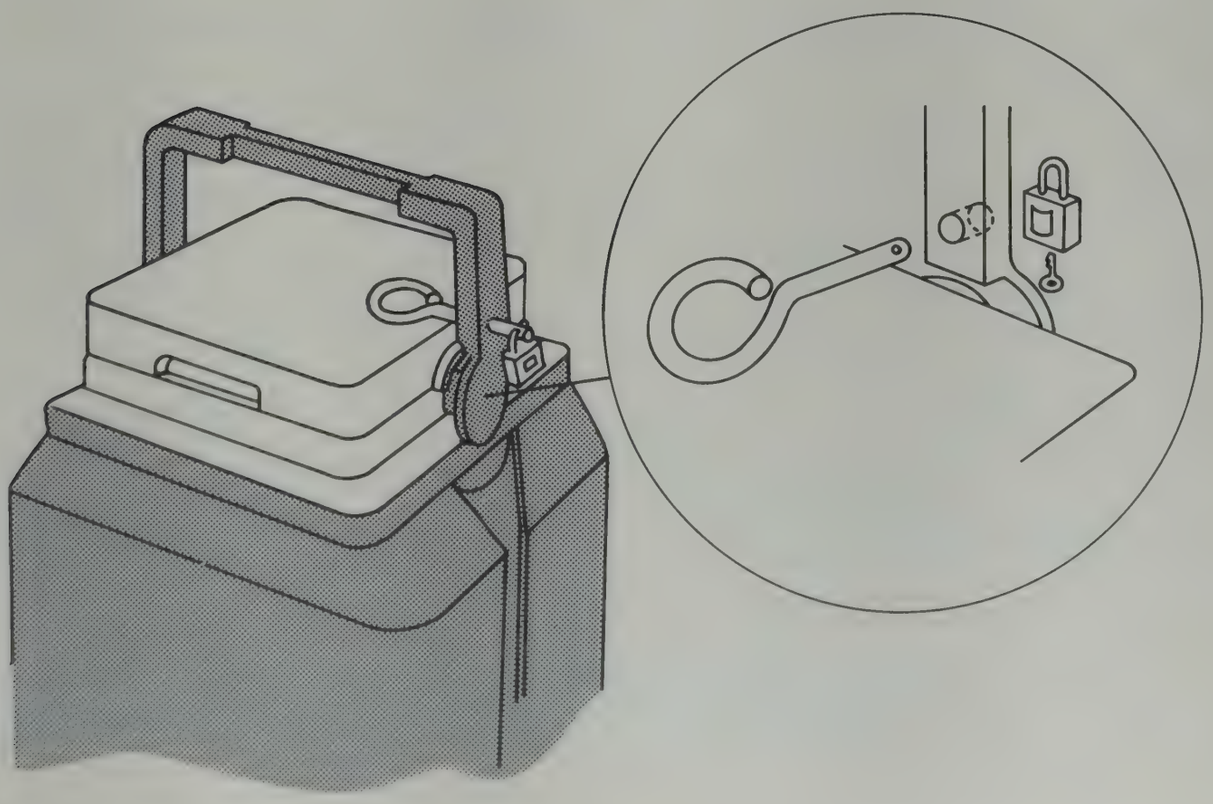
This section tells you how to make changes to a cold box to improve or make:

- the lock
- the lid seal
- the frame to carry it
- the insulation
- the straps to hold it onto a vehicle
- the ice pack frame and cold box divider

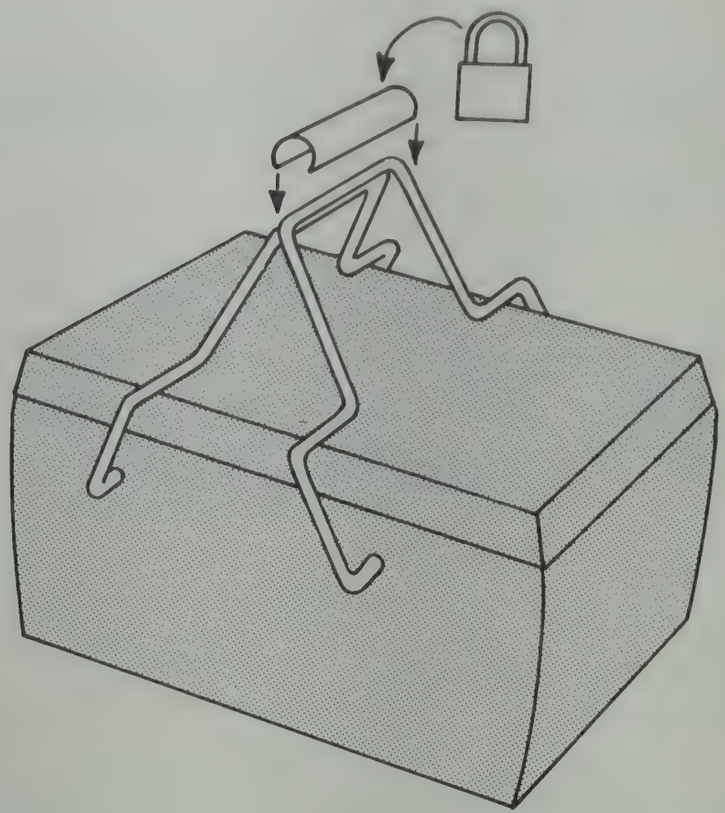
A cold box may suit your needs, but some changes or additions may be necessary to improve it.

Fixing a lock

Some cold boxes have a lid which locks when the handle is raised. With a large screw eye you can lock the handle in this position.



You can fit a simple lock to a cold box as follows:



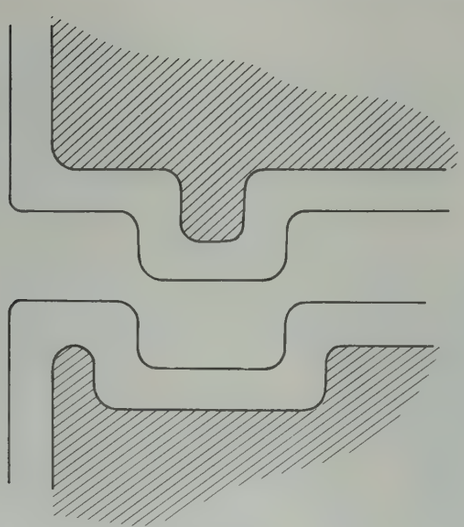
Handles locked by catch and padlock

If you buy a picnic box to use as a cold box, the three main points of weakness are likely to be:

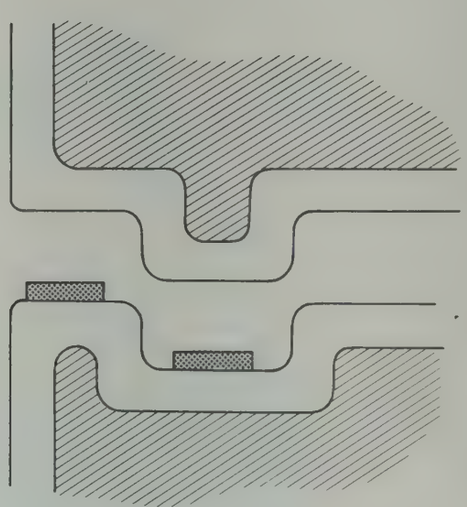
- the lid seal
- the strength of the outer shell
- the thickness of the insulation

These you can improve.

Improving the lid seal



before



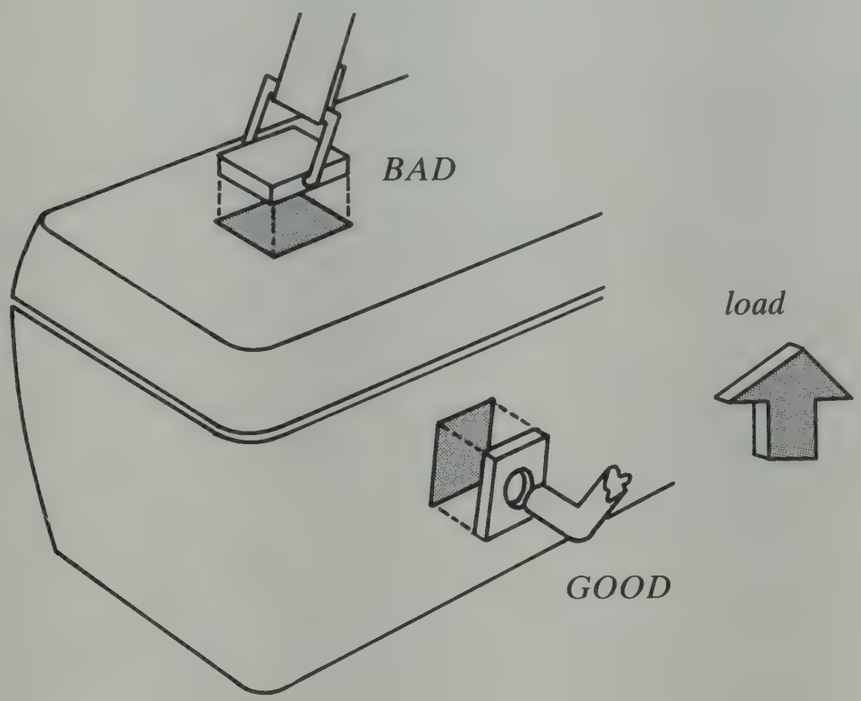
after rubber seals

You may use rubber seals or rubber paste, the rubber seals are glued in with rubber cement. If you use rubber paste, put a piece of waxed paper on top of the rubber paste so that it does not stick to the lid. When it has set, remove the paper.

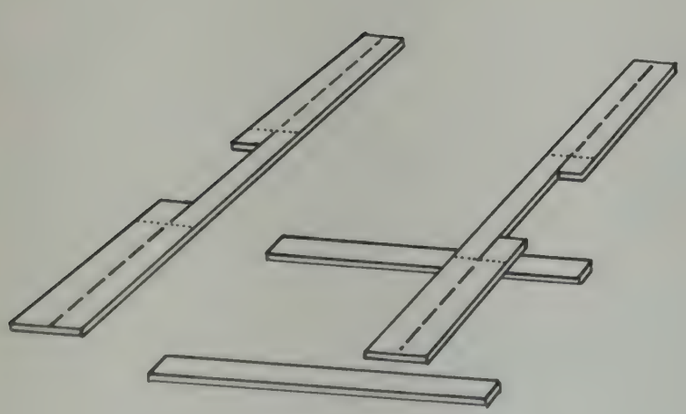
Making a carrying frame

If possible do not add any extra parts, such as a handle, onto a plastic box. The outer shell may not be very strong.

If you need to fix a handle, for example, it may be easier to glue it on. In this case, make sure the glue does not melt the plastic (see Annex III). Always make sure the glue line is in the direction of the load. And spread the load as widely as possible. Plastic breaks under concentrated loads.

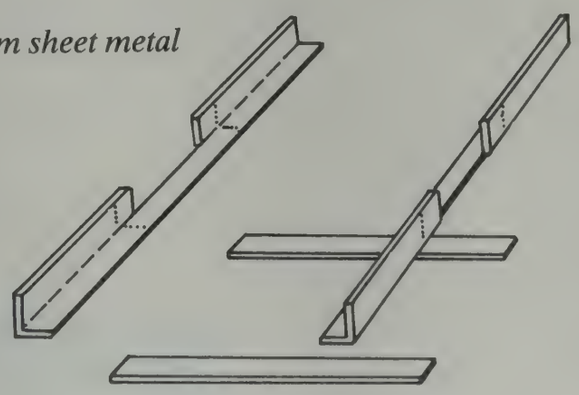


You can make a complete carrying frame from the following diagram, which will ensure you make no holes in the box.

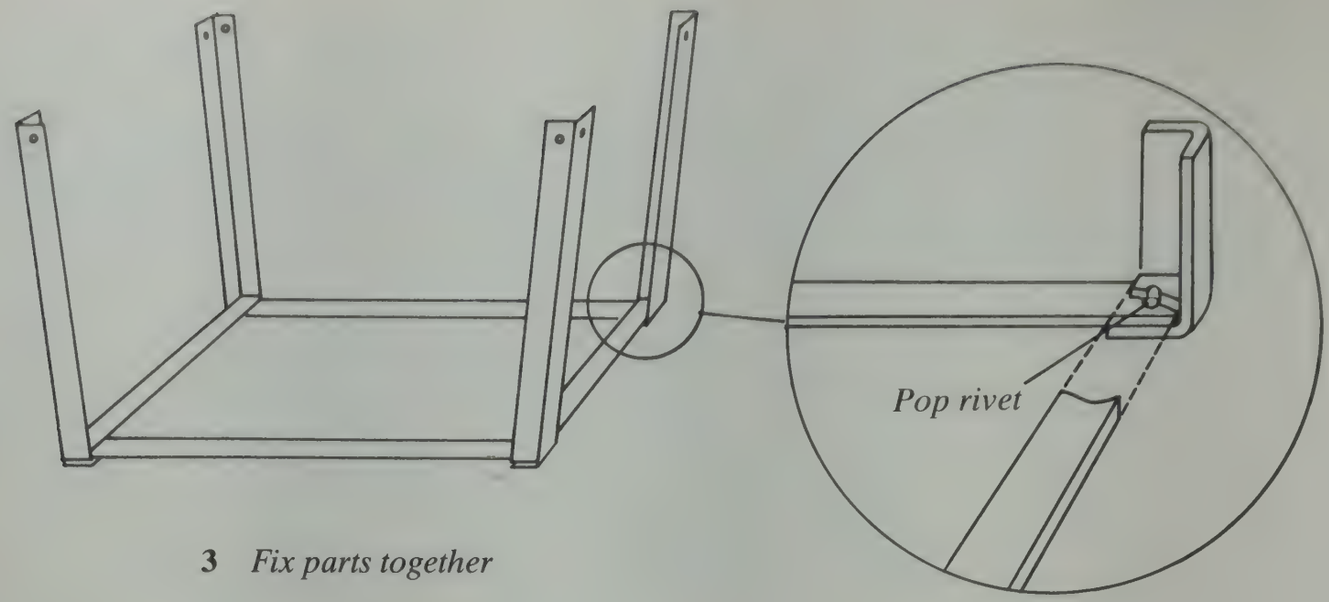


1 *Cut sheet metal*

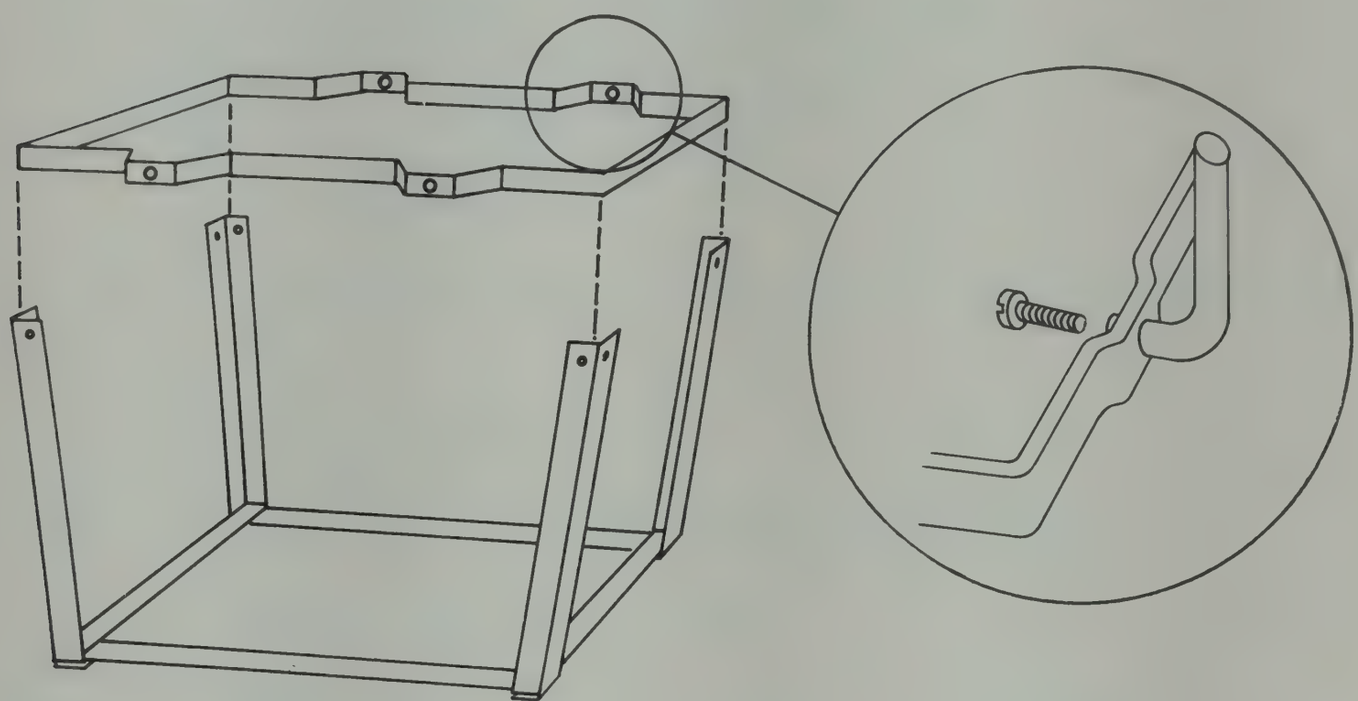
1–2 mm sheet metal



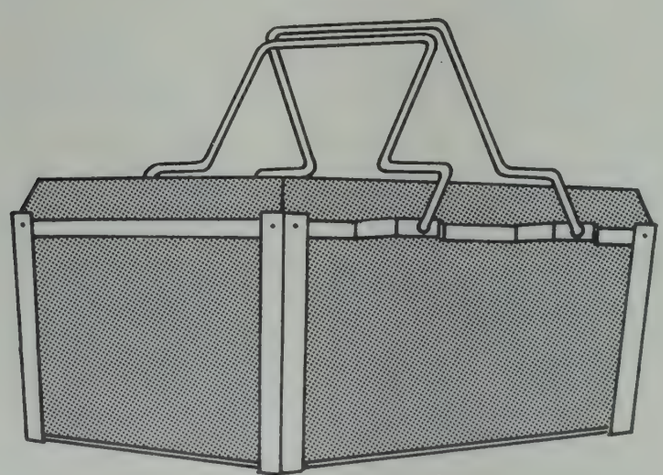
2 *Fold sheet metal*



3 *Fix parts together*



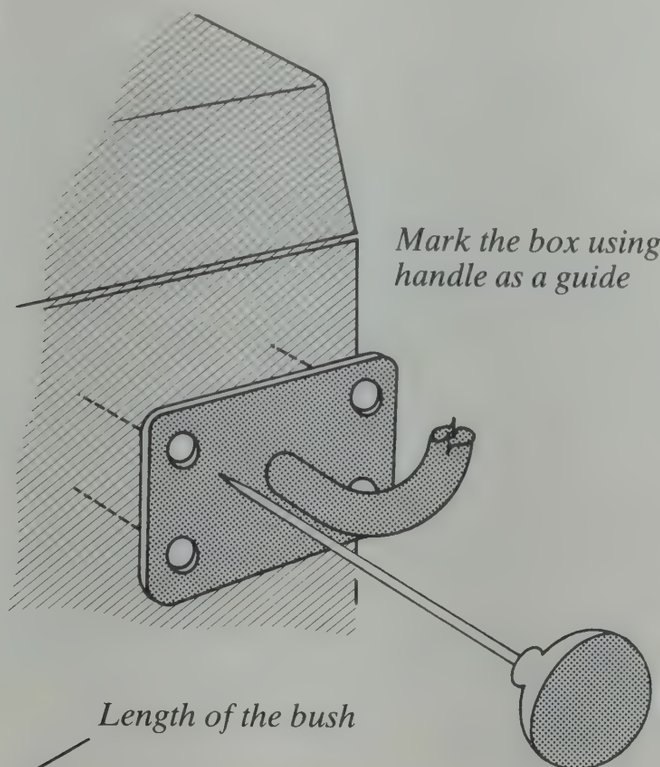
4 *Fix to frame and fit handles*



5 *Place cold box in new frame*

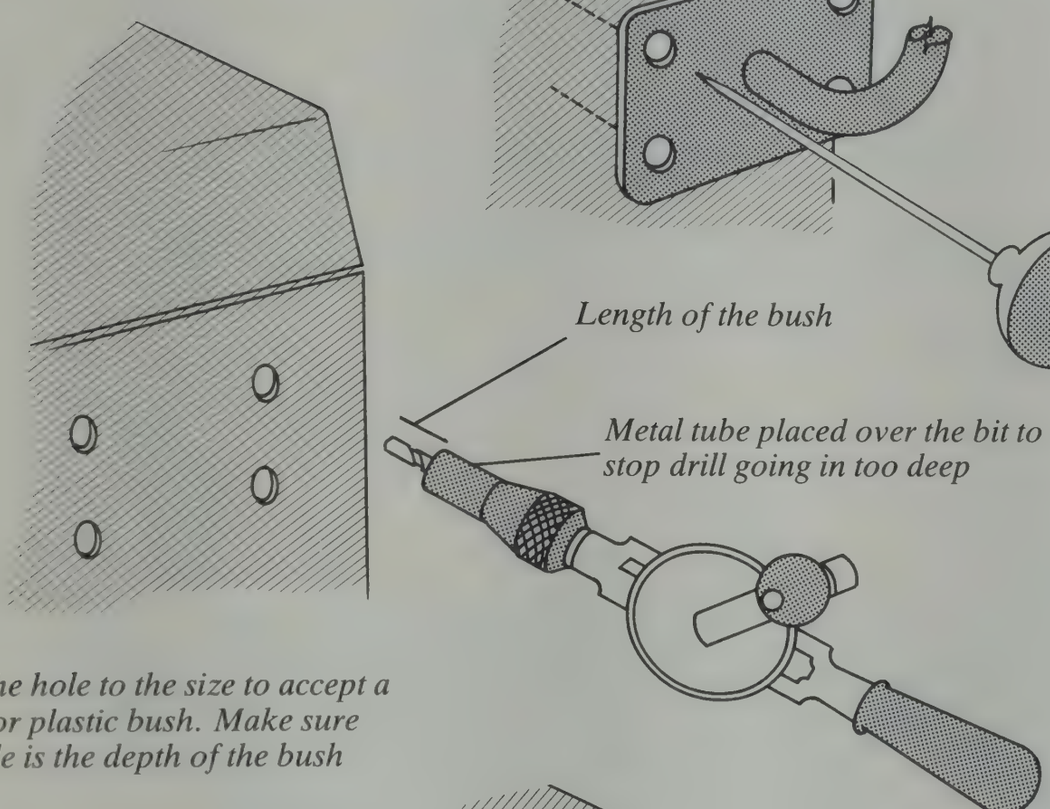
If you have to screw into the plastic add a metal bush first. Glue this into the box before putting in the screw. Make sure the glue is suitable for the plastic shell of the box and the insulation (see Annex III).

1



Mark the box using the handle as a guide

2

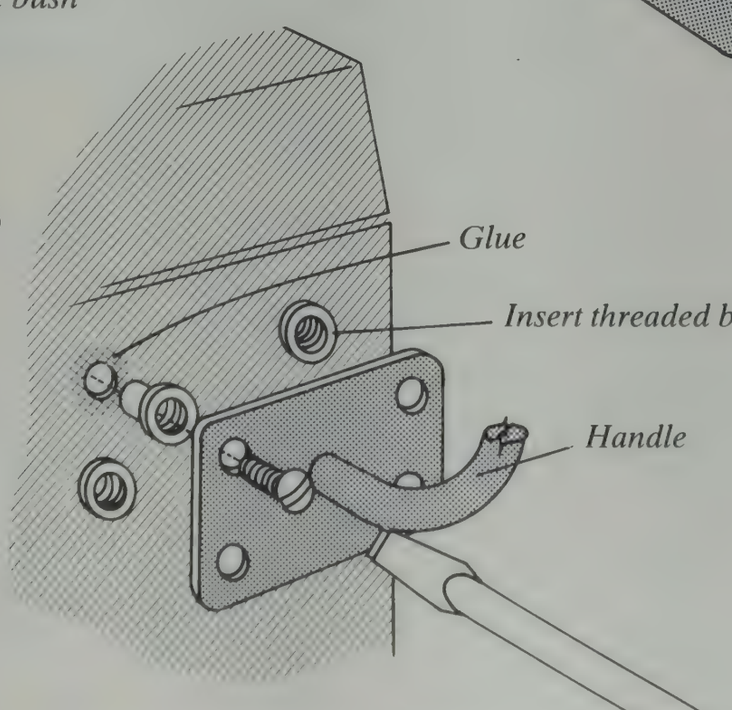


Length of the bush

Metal tube placed over the bit to stop drill going in too deep

Drill the hole to the size to accept a metal or plastic bush. Make sure the hole is the depth of the bush

3



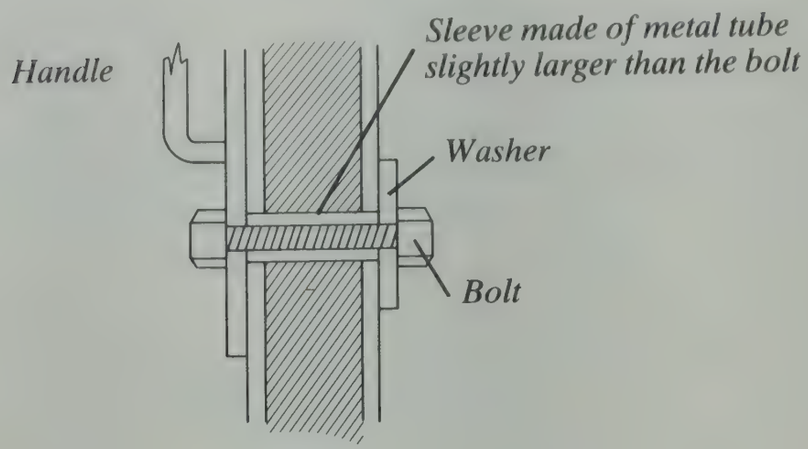
Glue

Insert threaded bush

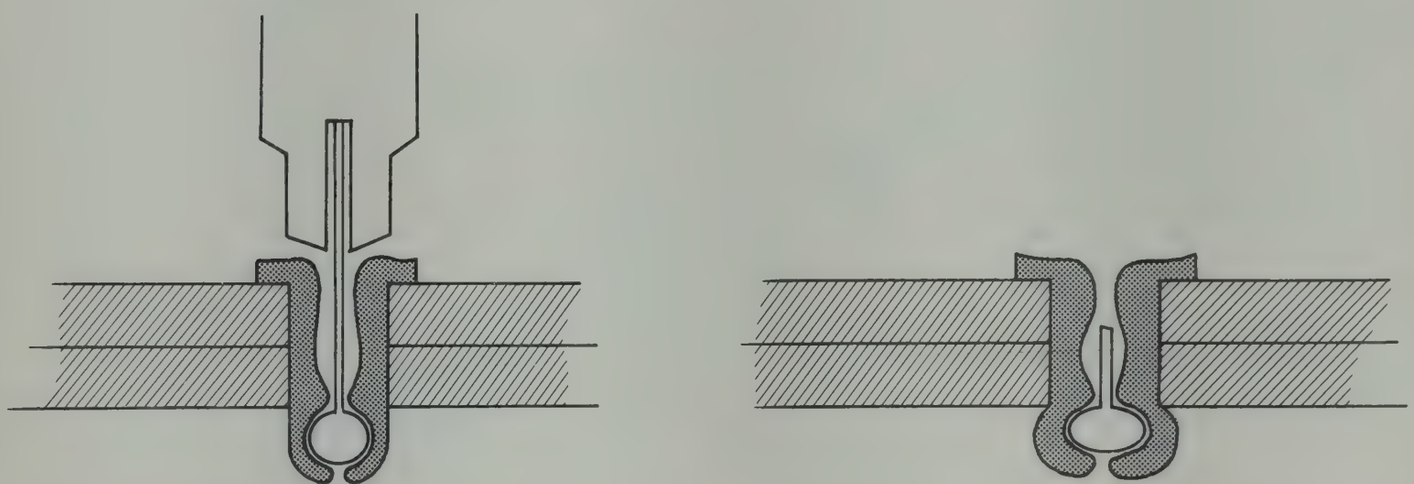
Handle

Glue the bush into the hole, when the glue is dry screw on the handle

If you do have to bolt right through the side of the box, make sure that the bolt is 'sleeved'. Otherwise you will crush the side of the box when you tighten the bolt. The bolt will act as a heat bridge and let heat into the box. So use bolts only if there is no other way of fixing.



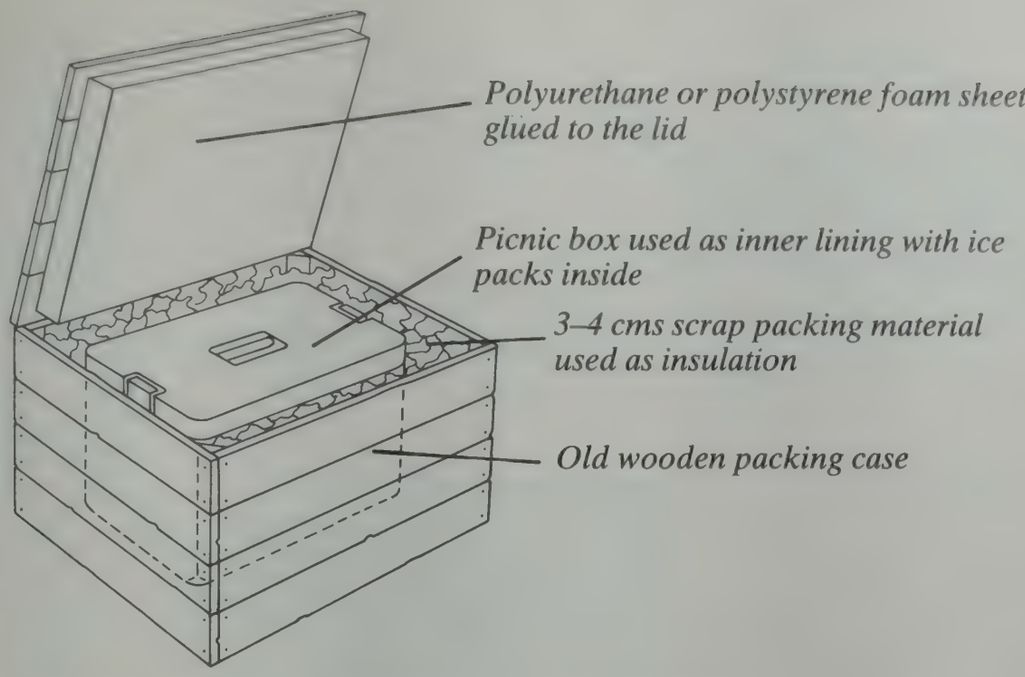
A very simple way to fix accessories onto a cold box is to use blind rivets. These can be fixed when only one side can be reached and will look like this:



A special tool is used to squeeze the two sides of the rivet together.

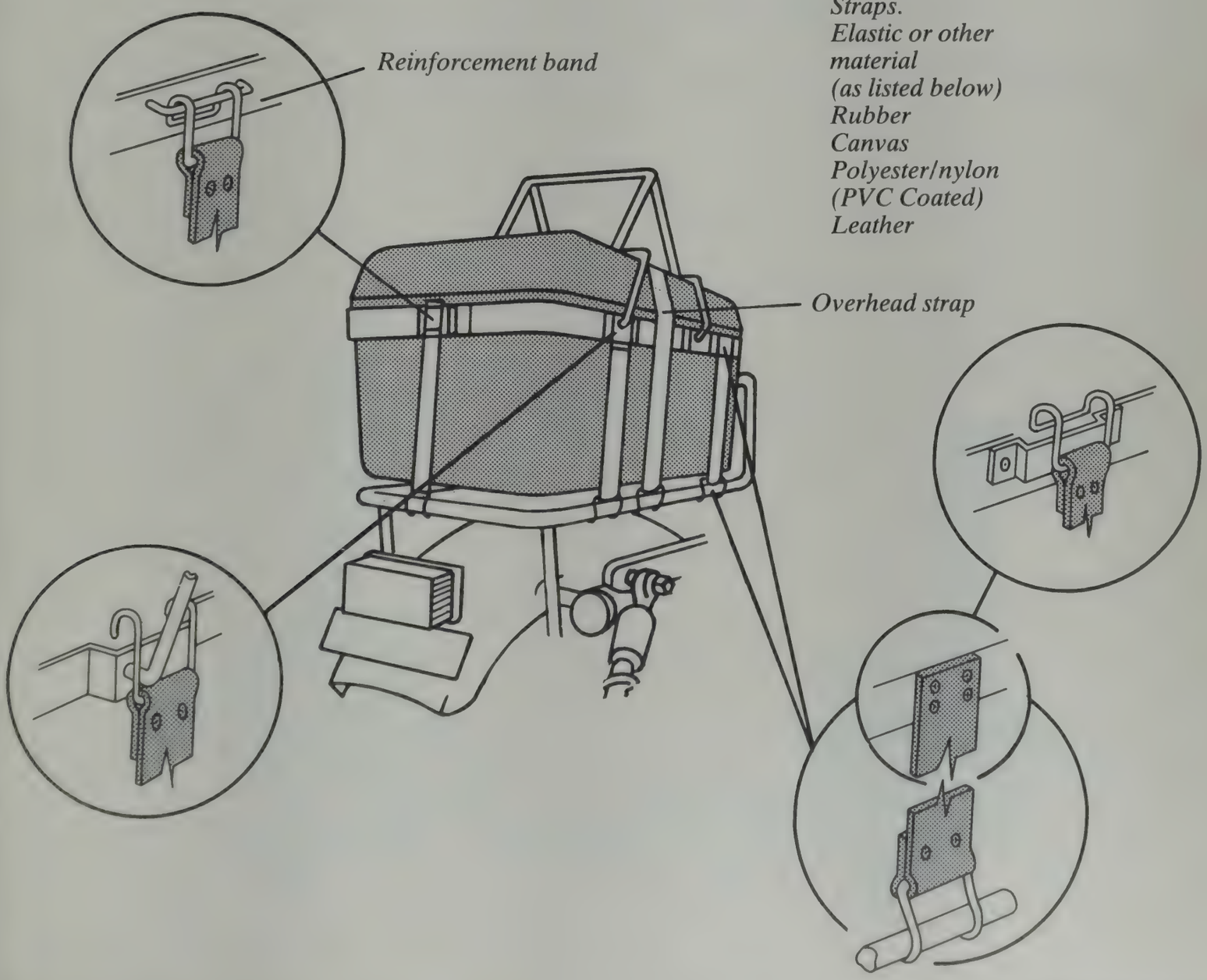
Improving the insulation

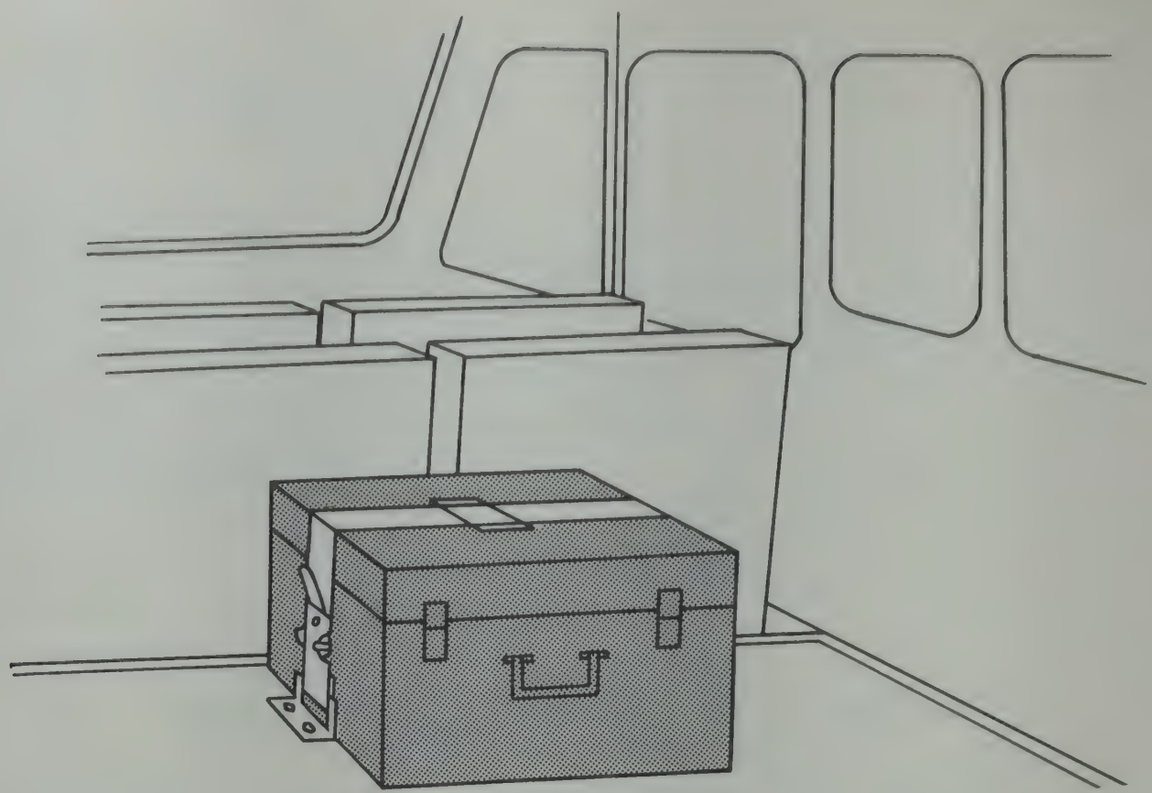
You can add sheets of polystyrene to improve the insulation of the cold box. But cover these with polythene sheets to keep the insulation dry. If you need to extend the cold life, it may be easier to put more ice packs into the box.

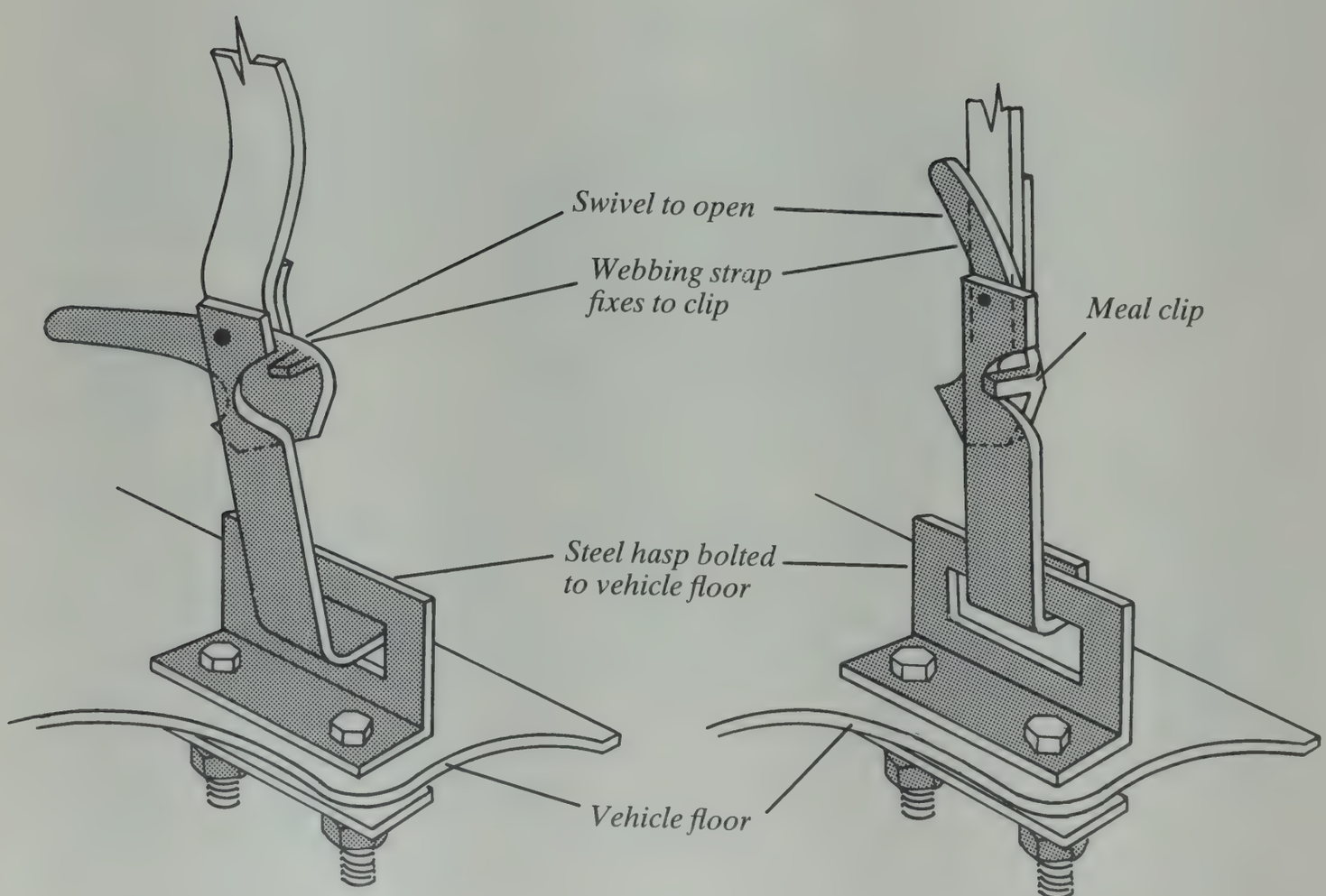


Fixing a cold box to a vehicle

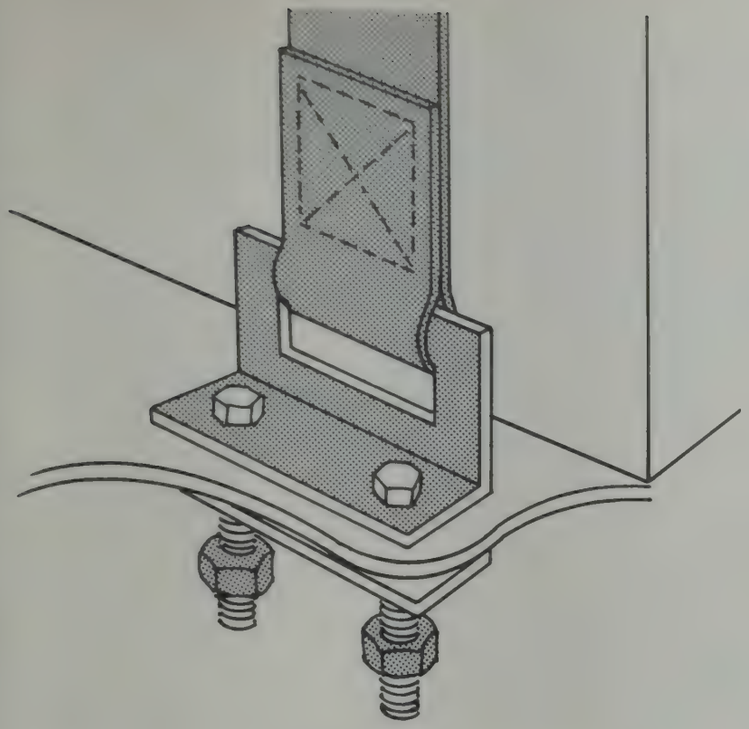
(alternative methods)



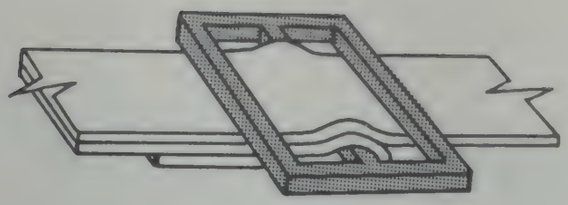




Closing catch



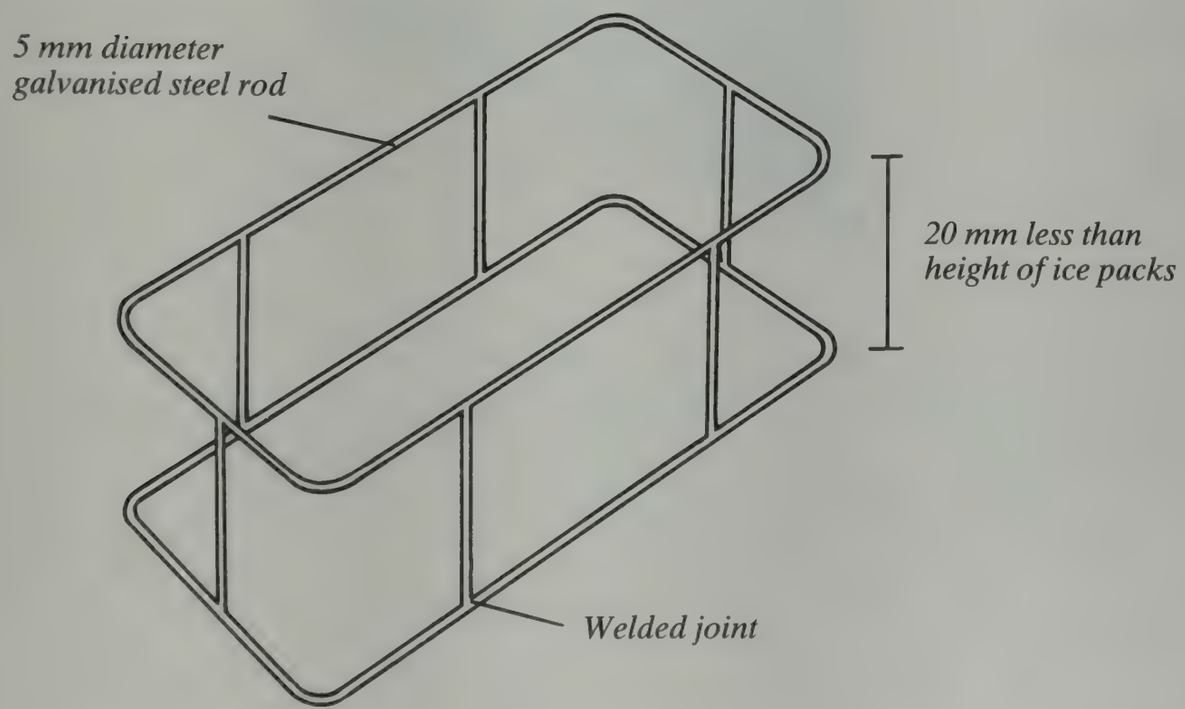
Fixed end



Adjustment buckle

Making a wire ice pack cage

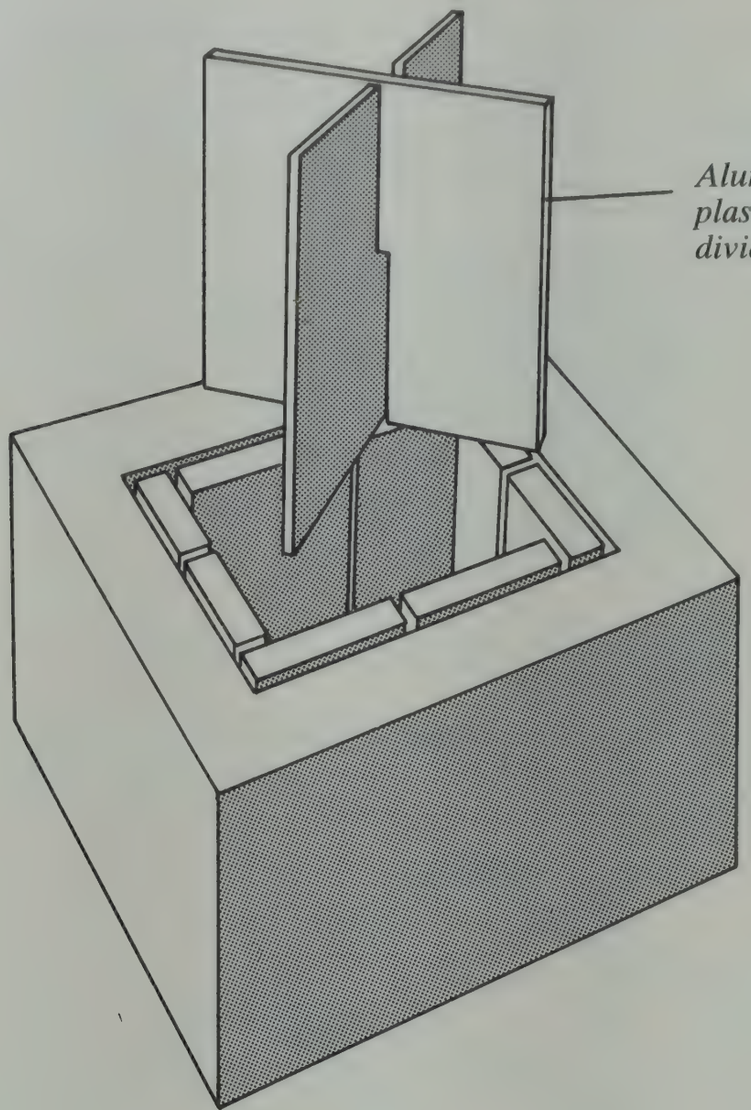
Very often ice packs become mixed up with the vaccine, especially after a long and rough journey. To avoid this you can make a simple cage. This keeps the ice packs round the side of the box.



Overall dimensions = internal dimensions of cold box
– thickness of 2 frozen ice packs

Making a cold box divider*

It is often easier to find the correct vaccine, if you divide the cold box into compartments. You can easily do this with a cardboard or plastic sheet as follows:



The divider fits into the corners of the box and makes spaces for four different vaccines.

**EPI Sana'a Yemen Arab Republic*

Section 4

How to write a specification for the local manufacture of a cold box

This section explains how you can tell a manufacture what type of cold box you need.

Writing a specification

The specification is an important document. It explains to a manufacturer what you will use the cold box for and how he is to make it. The following details help you to write a specification.

Description

First tell the manufacturer what you will use the cold box for. He will be experienced in the manufacturing process, but may not know about EPI. If he understands what the cold box is used for he can make a better box.

Example: To carry vaccines from the district store to the health centre, on the luggage rack of a bicycle. Only storekeepers at the district store and in the health centre will use it.

Construction

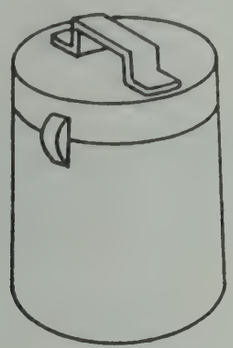
In this section describe what is essential to you as a user. The manufacturer will also make his own suggestions about the method of construction. This part tells him basic points which will influence his method of construction.

Example: The inside of the cold box will be seamless. The latches and locks will be recessed. There will be no sharp corners on the outside of the box.

Capacity, size and shape

State the capacity of the box and, if it is critical, the size and shape. Capacity is normally given in litres. Therefore decide how many litres of space you need to store the vaccine. This is called the net volume of the box. In addition you need space inside for the ice packs to keep the box cool. The size of the ice packs must be specified and the inside dimensions of the box should be given. The manufacturer decides the gross volume, overall size and shape once he designs the cold box. Also if you need a particular shape, describe it or possibly do a simple drawing.

Example: The net volume of the cold box will be between 10–12 litres. The overall shape will be as follows:



maximum diameter 25 cms.

Cold life

This is the most important point because it will make a big difference to the design. You should think very carefully about the amount of cold life as described in Section 1 page 3. It is described in hours at a set ambient temperature. State this time and temperature.

Example: The box will keep the temperature below 8°C for 80 hours at an ambient temperature of 43°C.

Weight

There are two ways to gain the desired cold life.

1. Increase the thickness of the insulation

2. Increase the number of ice packs.

Increasing the number of ice packs may make the cold box too heavy. If the weight is critical state the maximum acceptable weight. The spread of the weight may also be critical. If you carry the cold box on the back, the weight should be as near the body as possible. If you can freeze only a limited number of ice packs, state the greatest acceptable weight of ice packs. Remember you may state the impossible to achieve the cold life. So work very closely with the manufacturer as he is preparing his design.

Example: Maximum weight not more than 30 kg, when fully loaded with vaccine and ice packs. It should not have more than 8 kg of ice packs.

Durability

A cold box needs to resist:

- mechanical stress, either shock from dropping or scratching.
- chemical attack from the effects of sunlight (ultra-violet radiation and heat).
- water or water vapour. If water or water vapour get into the insulation it will be much less effective.

Decide how strong your box needs to be. Will you use it only in a health centre or take it out with mobile teams on dirt roads?
State the sort of test which the cold box should resist. And also state the condition the cold box should be in after the test. Remember there will almost certainly be some damage. It is important that the damage is easily mended. Durability is rated from 1–5 (see Section 7).
The plastic of the shell will resist scratches, keep out moisture and remain undamaged by sunlight.

Example: The box must stand up to the following test:
Drop the cold box full of ice packs from a height of 1 metre onto a concrete surface. Make a drop onto each face, edge and corner. On completion of this test, the condition of the cold box will be as follows:

Shell: there will be no more than surface damage (3 on a scale 1–5). The damage will be easy to mend and should not harm the insulation. The plastic of the shell will resist scratches, keep out moisture and remain undamaged by sunlight.

Hinges and catches: these will remain undamaged and still work.

Lid seal: this will remain effective.

Finishes

The finish on a cold box is important both inside and outside. The inside should be smooth and shiny, as this helps to reflect cold and keep it inside. The outside should also be smooth, easily cleaned and if possible, not need painting.

Example: The internal finish will be smooth and shiny. The outside finish will be white with a smooth, easily cleaned surface. All handles, hinges catches and screws will be rustproof.

This completes the specification. You are now ready to discuss it with a manufacturer. When you do discuss it, listen to his suggestions and decide if they influence your specification.

Example of a specification

• Description:

Use: to carry vaccines from the district store to the health centre on the luggage rack of a bicycle. Only store keepers at the district store and in the health centre will use it.

• Construction:

The inside of the cold box will be seamless. The latches and locks will be recessed. There will be no sharp corners on the outside of the box.

• Capacity, size and shape:

The net volume will be between 10–12 litres. The overall depth will not be more than 20 cms.

The size of ice pack to be used is 10 cms wide and 18 high and 2 cms thick.

• Cold life:

The box will keep the temperature below 8°C for 80 hours at an ambient temperature of 43°C .

• Weight:

Maximum weight not more than 20 kg when fully loaded with vaccine and ice packs, it should not have more than 4 kg of ice packs.

• Durability:

The box must stand up to the following test:
Drop a cold box, full of ice packs, from a height of 1 metre onto a concrete surface. Make a drop onto each face, edge and corner. On completion of this test the condition of the cold box should be as follows:

Shell: There will be no more than surface damage (3 on scale 1–5). The damage will be easily mended and will not harm the insulation. The plastic of the shell will resist scratches, keep out moisture and remain undamaged by sunlight.

Hinges and catches: These will be undamaged and still working without leakage.

• Finishes:

The internal finish will be smooth and shiny. The outside finish will be white with a smooth easily cleaned surface. All handles, hinges, catches and screws will be rust proof.

Section 5
Dealing with a manufacturer

This section describes:

- how to choose a manufacturer
- the manufacturer's techniques
- making a contract

How to choose a manufacturer

There are five main points to consider when you are looking for a manufacturer.

1. His knowledge of the manufacturing process. He may not know about cold boxes but he must know about the materials he works with.
2. The size of the work force and the suitability of their skills.
3. The stocks and supplies of materials.
4. The suitability of his equipment.
5. The financial health of his business.
   If you are not satisfied on these points, the manufacturer will probably not be suitable.

How will you consider these points?
The following will help you make your decision.

Manufacturer's knowledge

Use the information described later in this section to discuss the manufacturing problems with him. He may not know about cold boxes, but he will know the design limitations of his materials and the production methods.
Ask to see any other products like cold boxes which he has made. Talk to other people for whom he has made things. See if they are satisfied with the product.
Find out if he delivered the product on time.
Satisfy yourself that he is interested in helping with the design.

Work force

Ask him to show you round the workshop. Check if it is well organised. Are the people there doing a good job? Do they seem cheerful and satisfied? Talk to the workshop foreman and to people on the shop floor. They are the people who will make your cold box. And if they are not interested in the work and their work is careless, you will not get a good product.

Materials

Ask to see his stores and check his supply system. If he has to import materials, he should have 3–6 months reserve of supplies. With imported items check that there are no limitations, such as set government quotas. If he buys from a local wholesaler, visit the wholesaler and check his supplies. Make sure he is looking after the raw materials and keeping them carefully. Make sure he has enough stocks and supplies of the bought-in parts, like handles, hinges, locks, lid seals and lid stays.

Equipment

When you are looking round the workshop, ask to see his equipment. If he is working in plastic see if he has any of the following:

Blow moulding machine

Injection moulding machine

Vacuum forming machine

Hot bending machine

Hot gas welding equipment

Foam injection equipment

Hot wire cutting equipment

These machines and equipment are described on pages 34–36.
Check that the equipment is in good condition and clean and that he keeps hand tools neatly.
Ask if he keeps spare parts for the machinery and how he has them mended if they go wrong.

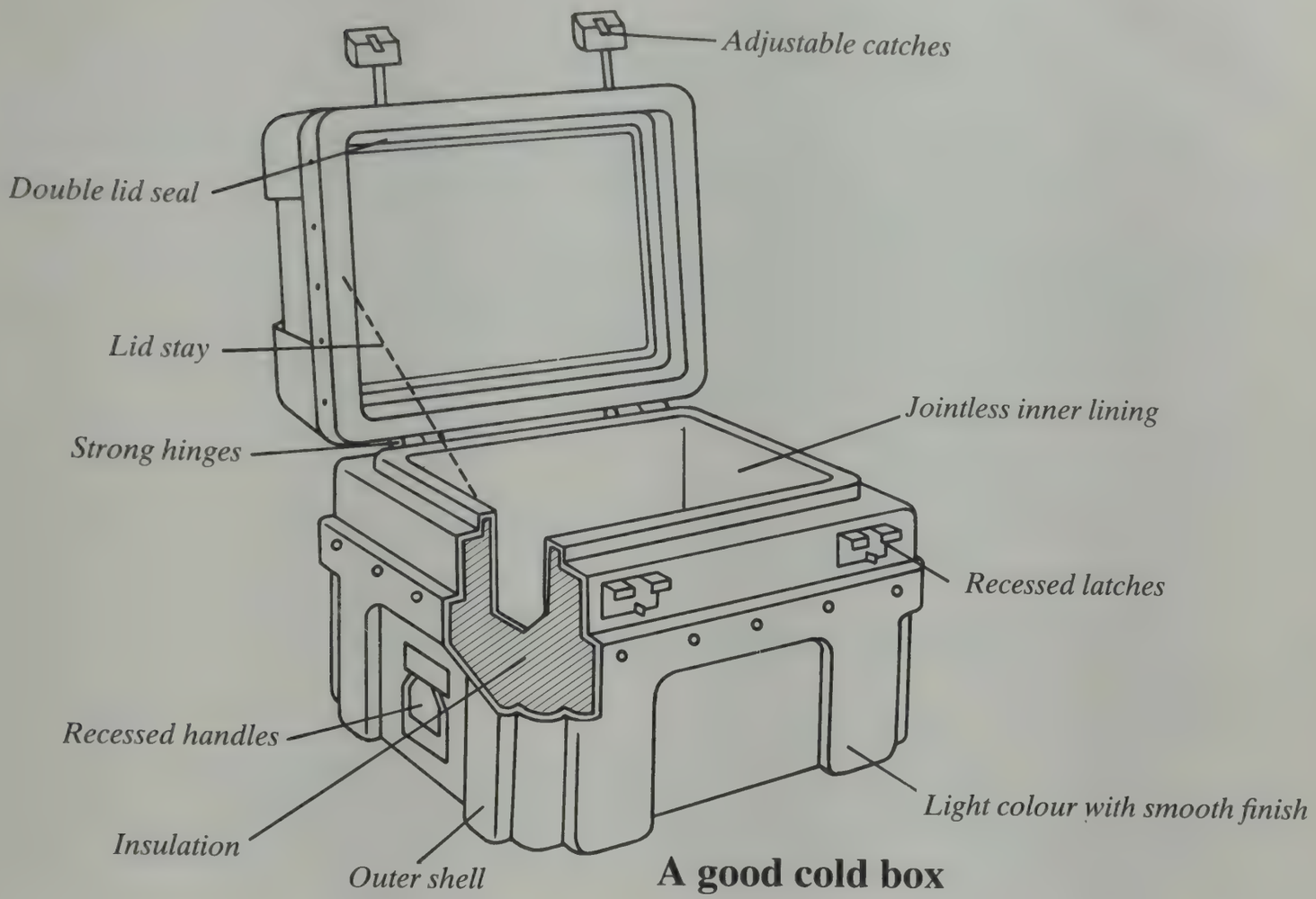
Finance

It is important to satisfy yourself that the manufacturer's business is healthy.

You can do this in several ways:

- ask him to show you a copy of his audited accounts for the last year.
- check with other customers that he keeps to his prices.
- check with his suppliers that he pays his bills.
- ask for a bank reference.
- ask to see his order book. If he has a lot of work he may only be interested in your job if it is very large. On the other hand, if he has very few orders, he may be about to go out of business.

With all these points you must make up your own mind. There are no hard and fast rules to follow. Just check the manufacturer as well as you can, and then decide.



A good cold box

The manufacturer's techniques

You need to understand what the manufacturer is talking about during your discussions. You will also find it easier if the manufacturer does not have to explain the basic methods. The following are the main techniques and materials he may use.

Plastics

Materials

There are many types of plastics but only a few are suitable for cold boxes. The best material is called polyethylene. It is very strong and weatherproof. Another suitable material is fibre glass reinforced polyester, usually called FRP or GRP. This material has many advantages for local manufacture. For example:

- making new designs is not expensive and does not need expensive equipment.
- it can be moulded to many shapes.
- it is easy to put together.
- it is a well understood technology, because it has many other applications eg. mending vehicles.

In addition there are the following materials which are suitable for inner linings of cold boxes or for ice packs:

Polypropylene (pp)

Polyvinylchloride (pvc)

High density polyethylene (HDPE)

High density polystyrene (HDPS)

GRP, which is often used, depends for its strength on the type of fibreglass used. There are four forms of fibreglass:

Chopped strands

Rovings, which is like open weave

Mats, which are mixed strands matted together

Woven fabric (this makes the strongest GRP)

Techniques
Moulding:

There are a number of ways of moulding plastic. There are however, two main classes, with heat and without heat.

Hot moulding (main methods)

○ Blow moulding

Description: A plastic tube is put into a mould, which is sealed at the bottom. The tube which is hot, is blown up like a balloon to take the shape of the mould and then removed when it has cooled. This method is suitable for making small light containers, such as ice packs.

Advantages	Disadvantages
It is more common	It is usually only for small products except with very expensive equipment
It is cheap for large quantities	The original mould is expensive
	The thickness of the wall may vary, especially at the corners
	Needs large scale production

○ Vacuum forming

Description: A hot plastic sheet is stretched over a mould. The mould then sucks it in by vacuum, to take its shape. This method may be used for the inner and outer shell of cold boxes.

Advantages	Disadvantages
It is fairly simple	It cannot make a seamless shell
It is less expensive	

○ Hot bending

Description: A plastic sheet is heated in an oil bath and then bent over a wooden mould. A part of it is heated over an electric coil and then bent into shape. This method is used to make simple bends in plastic sheet.

Advantages	Disadvantages
It is very cheap	It only makes 1 dimensional simple bends

Cold moulding (main methods)

Description: Layers of glass fibres and polyester resin are placed in a mould. With an open mould only one side has a smooth finish, with a closed mould both sides have a smooth finish. This method is used for making the shell of cold boxes.

Advantages	Disadvantages
It does not need heat	It cannot produce seamless moulding
It is a common skill	It needs careful preparation
It is less expensive	Very expensive for closed moulds
Open moulds do not need complicated equipment, it can be done by hand	Only one side is smooth with open moulds
It is economic for small quantities	

Jointing

Once the shells are made they must be joined together to make the body of the cold box. There are several ways of doing this. The following are suitable for thermoplastics:

○ Adhesive bonding

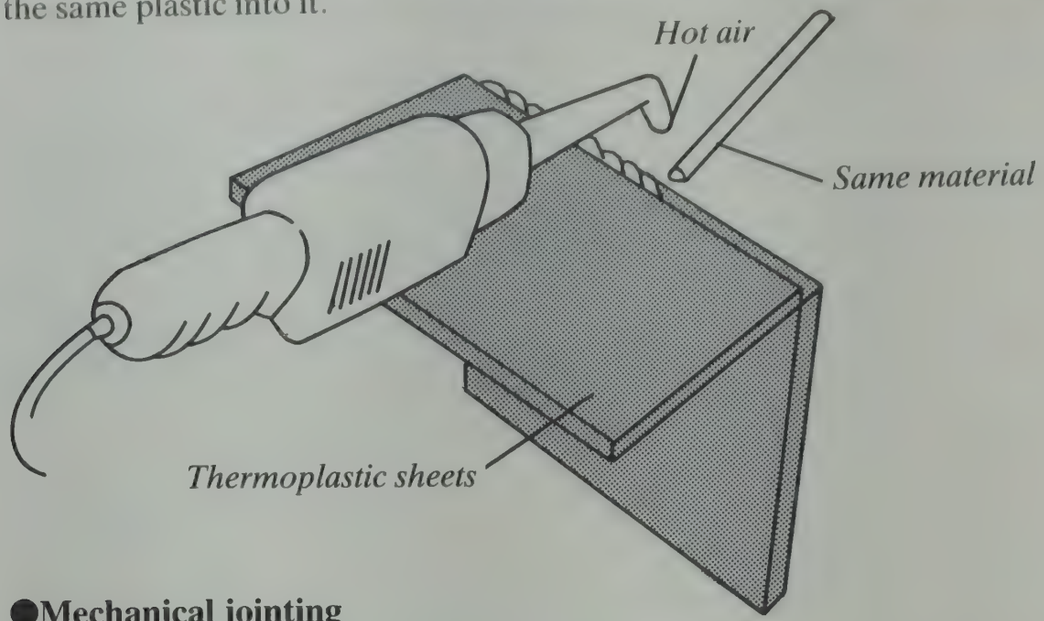
This uses a resin glue, which must be suitable for the type of plastic being bonded. If it is not suitable, it damages the plastic (see Annex III). The joints need careful preparation and cleaning before bonding. There must be strict quality control to make good joints. Check with the manufacturer how long the bonding resin lasts.

○ Solvent bonding

This method uses a chemical which softens the plastic. The softened joints are then pressed together and left for some time until the plastic hardens again. The chemicals commonly used as solvents are MEK (Methyl Ethylene Keton) and TRI (trichloroethylene). Only certain types of plastic can be joined in this way. They should not be used on Polystyrene foam isulation as they will disolve it.

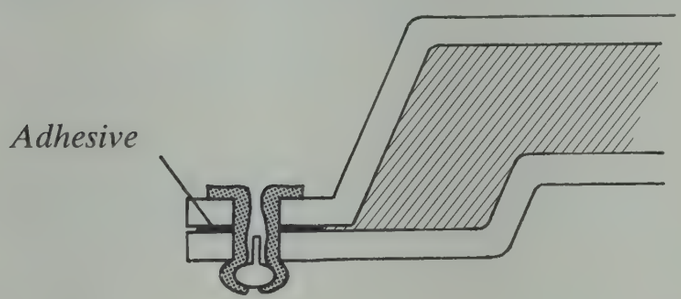
●Hot gas welding

This method uses a welding torch to produce a thin stream of very hot air. This melts the plastic to be joined. The gap in the joint is then filled by melting a rod of the same plastic into it.



●Mechanical jointing

This method joins plastics with rivets. The joint must also be made waterproof. To do this waterproof adhesive is put into the joint before riveting.



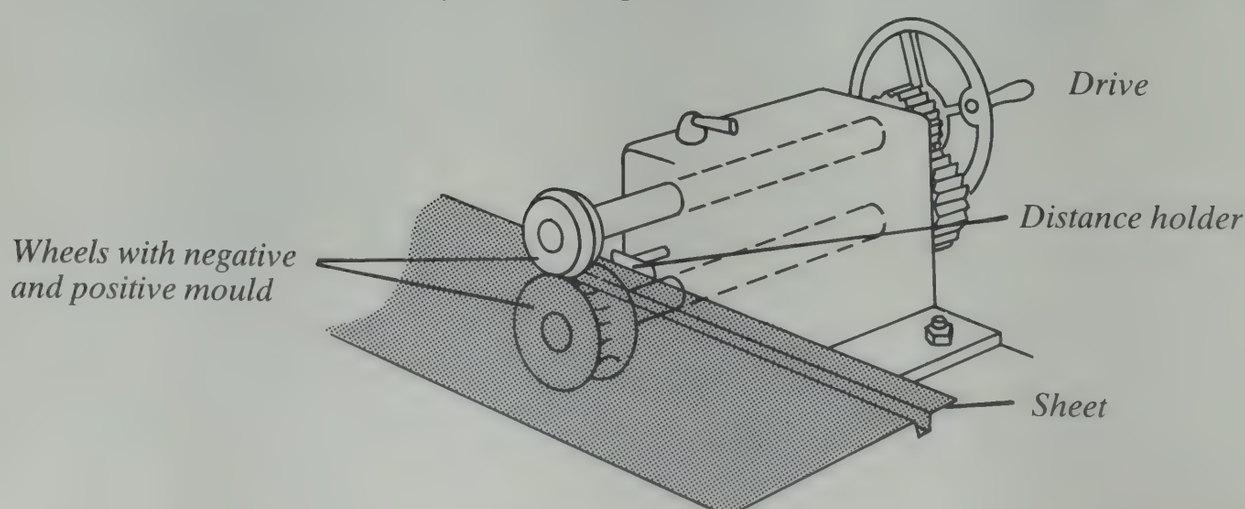
Metal

●Materials These are described on page 8

Techniques: Metal can be used to make the whole cold box or to strengthen another material such as wood. Sheet metal is usually 0·5-1mm thick. If it is thinner than this, the edges and corners need strengthening.

Sheet metal working:

This is the commonest method of working metal. The shell of the box is cut from metal sheets, which are then folded into shape and joined. Large sheets may need to be stiffened by roll forming. This is done on a machine like this.



Advantages	Disadvantages
It does not need expensive moulds	It has a large number of joints
It is a common skill	It needs considerable skill to make a good product
You can make many shapes	
It is good for limited quantities	

○ Pressing and stamping:

These methods use simple machinery to press sheet metal into the shape you want for making catches, handles and hinges.

○ Metal spinning:

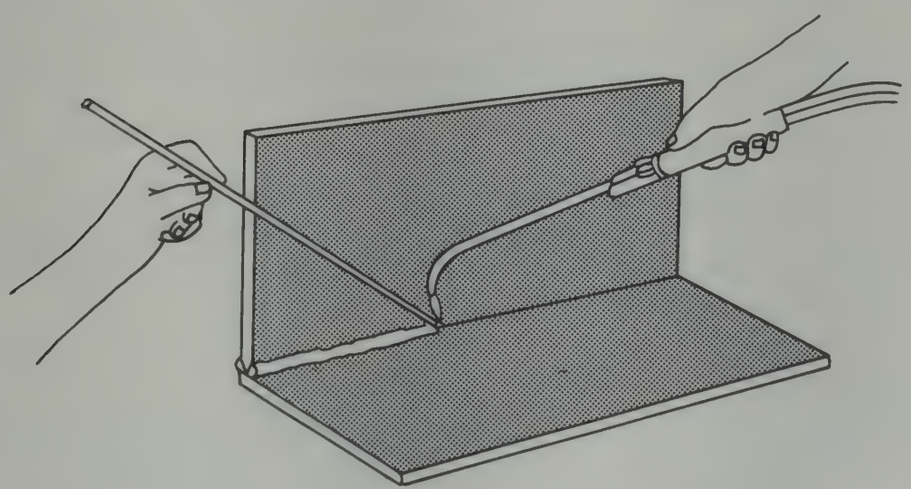
This technique uses a lathe to spin metal sheet which is then pressed over a mould to make cylindrical shapes like a drum.

Advantages	Disadvantages
Simple	Limited to cylindrical shapes
Cheap	Small quantities only
Common skill	

Jointing:

○ Welding

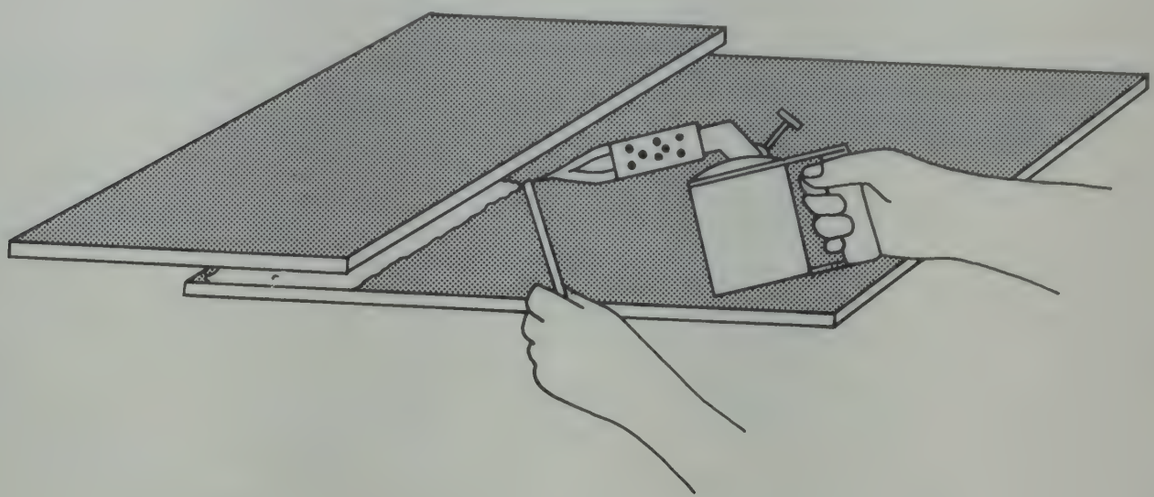
Gas: this method uses a welding torch to melt the metal at the joint. It makes a very strong and vapour-proof joint if it is done well. The metal needs to be thicker than for other types of jointing. A welded joint should look like this.



Note that the joint is welded on both sides and the weld itself is continuous. There are no little holes in it.
Welding equipment uses a mixture of oxygen and acetylene gas to burn a very hot flame. The operator must use a mask or goggles to protect his eyes from the bright light of the heated metal. When the metal is heated, there are many sparks. So it must be done in a special place set aside for welding.
Electric: this uses electricity to melt a metal rod and so seal the joint.

○ Soldering

This method uses less heat and so makes a less strong joint. It is used to join thinner metal sheets. Heat is applied with a blow lamp. Solder is then melted into the joint. The joint must be absolutely clean and close fitting. Otherwise the solder will not make a good joint. Soldered joints should look like this.



Unlike welding the solder flows, when the metal is hot enough to melt the solder. So the joint is very narrow. The blowlamp usually burns kerosene. As there are no sparks and the light is not so bright, the operator does not need protective goggles. Solder is a mixture of lead and other soft metals. Hard solder is called silver solder and this may be used to make a stronger joint, but it is more expensive.

○ Brazing

This is like soldering but uses a harder material called braze. It gives a stronger joint. Braze is made from brass and like solder comes in sticks.

○ Riveting

Riveted joints will only be vapour proof if a waterproof strip is put into the joint. Metal riveting is like the plastic riveting described on page 22. It is not used for joints inside a cold box. If blind rivets are used, the rivet can be fixed when only one side is accessible.

○ Bolting

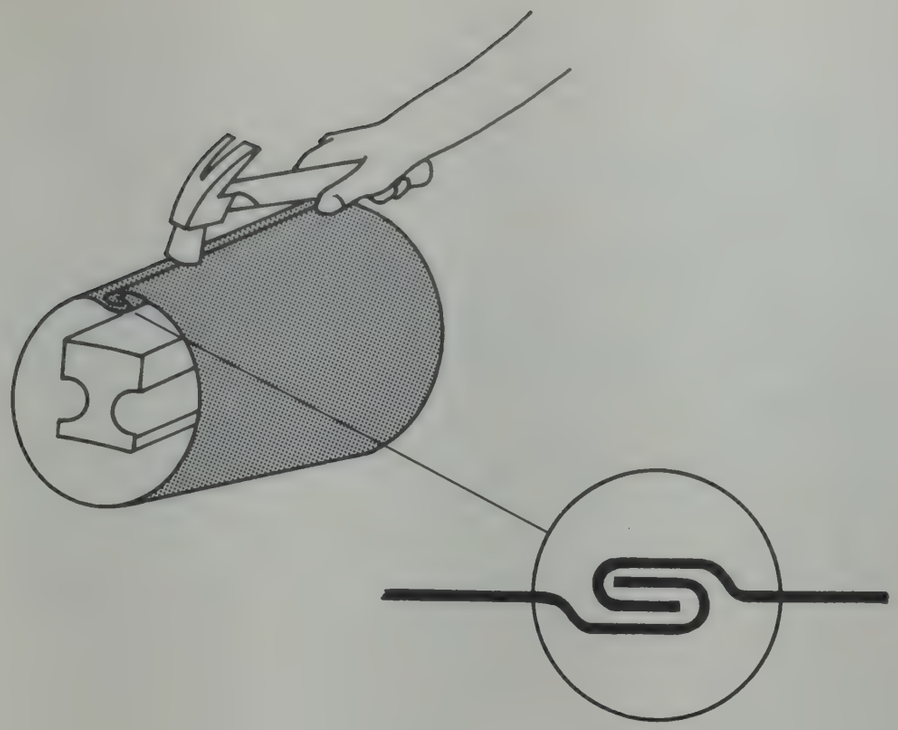
This is useful for joints where there is going to be considerable pressure. The bolts are much bigger than rivets. But they are easier to remove, if you ever have to open the joint. If the metal is not thick enough to thread, there needs to be a nut for the bolt to screw into. This is not suitable for sheet metal if the back of the sheet is not accessible.

○ Self tapping screws

Their advantage is that you can remove them easily, if you have to open the joint. They are much lighter than bolts and do not need nuts. But they are much less strong.

○ Rolling

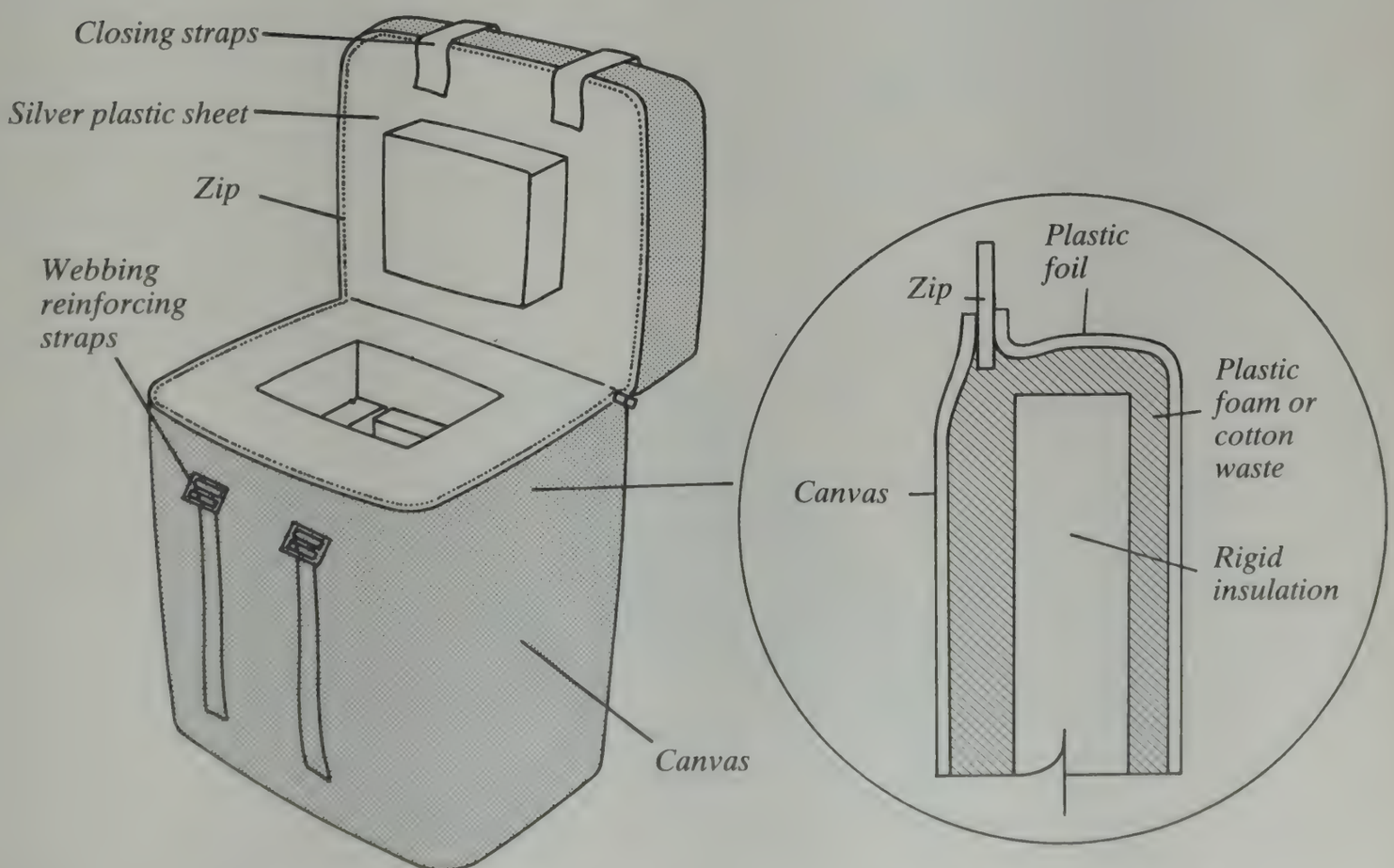
With this method edges of the joint are bent together so that they lock. The joint looks like this.



A machine can also make this type of joint. There are various forms of rolling depending on how strong the joint has to be. It is only vapour proof if it is soldered.

Fabric and leather

There are very few examples of soft cold boxes. The sketch below shows one that has been designed for making from canvas.



Some boxes are available with canvas outer cases and rigid plastic linings.

Wood

Materials

The most suitable types of wood are described on page 8.

○ Glue

In addition to the wood that is used the right type of glue is also important.

The glue must be resistant to:

- Moisture
- Sunlight
- Insect attack
- Dry heat
- Cold

The best glues in order of choice are:

- Phenolresorcinolformaldehyde
- Phenolformaldehyde
- Melamine formaldehyde
- Ureaformaldehyde

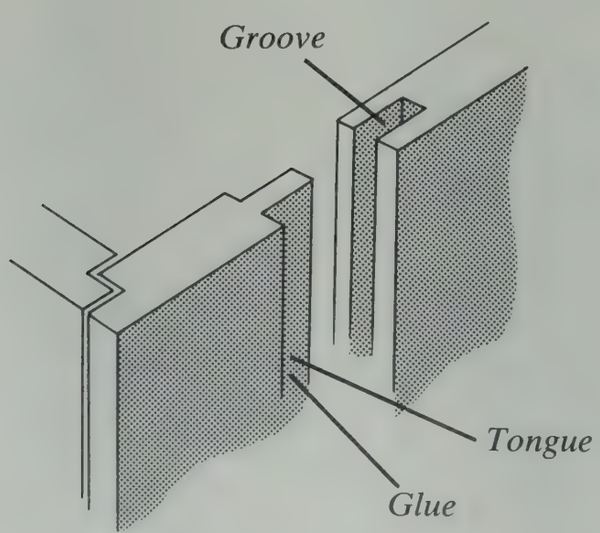
Do not use:

- Animal glues (casaine)
- Starch glues
- Polyvinyleacetate glues (pva)

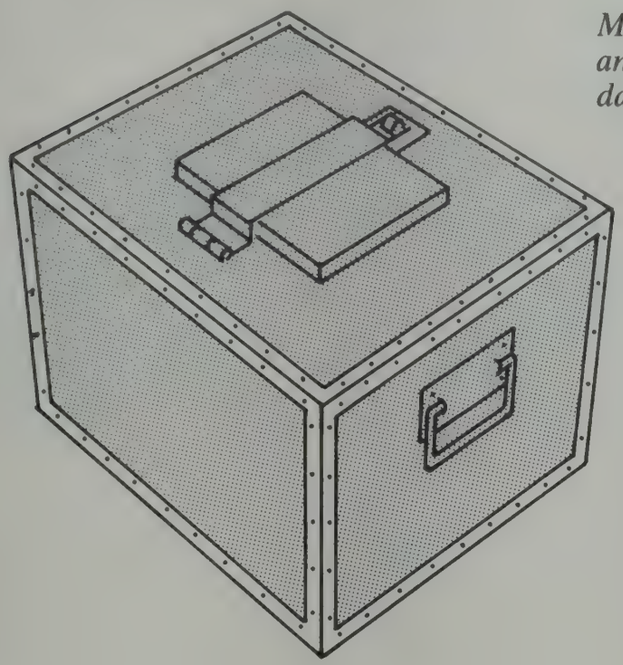
Techniques:

○ Framing

Wooden boards need a timber or metal frame to support them. The boards need to be tongued and grooved like this:

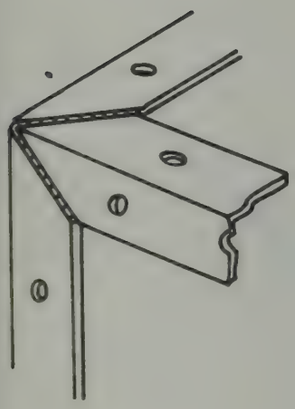


You may find that boards are more common than plywood. Hardwood boards will not need treatment against termite attack. The edges of the box can be protected with metal angles like this:–

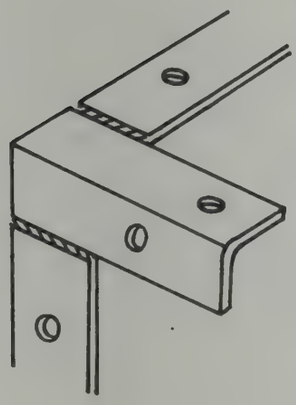


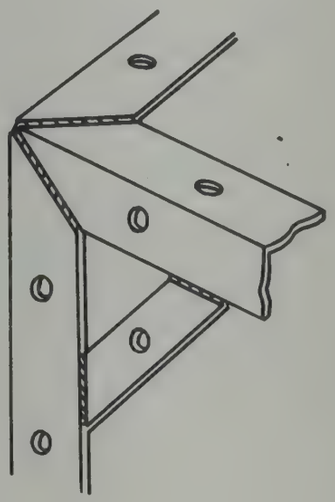
Metal edges as a framework and as protection against damage

Welded frame constructions and edge protection

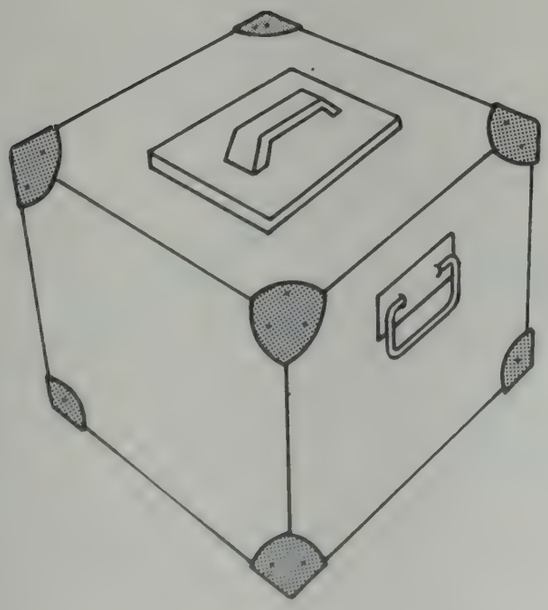


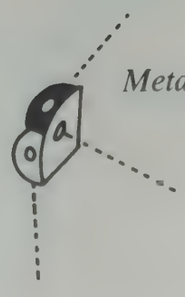
Screwed edge protection





or with metal corners only like this:



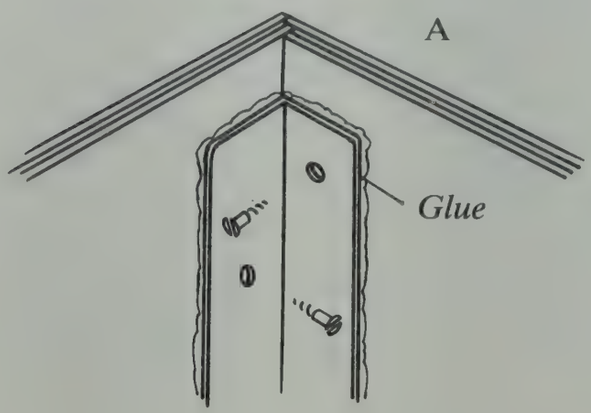


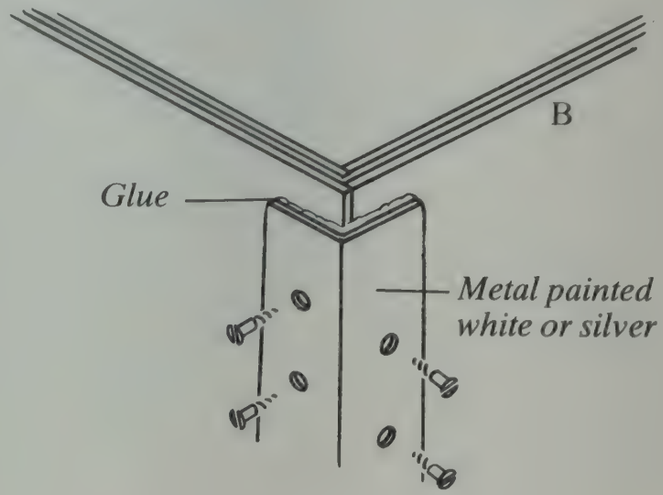
Metal corners

○ Plywood construction

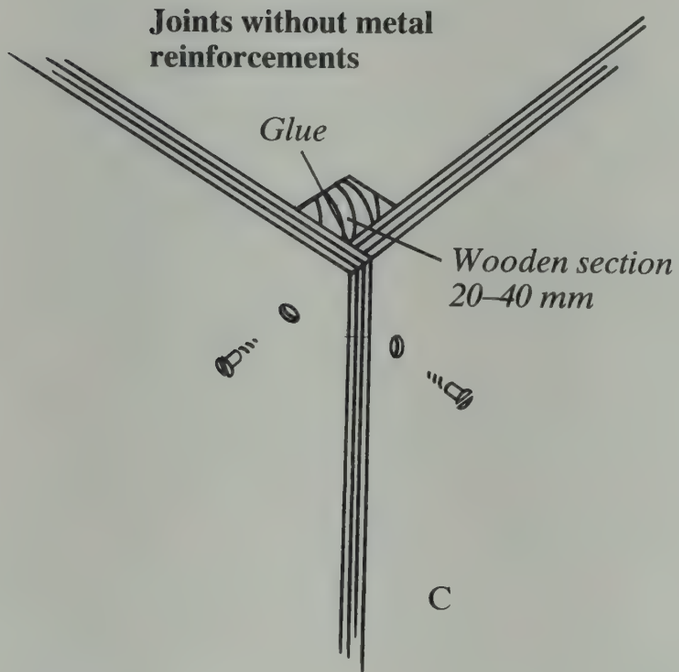
If the plywood is 12–15 mm thick framing can be lighter or it may be omitted altogether. With metal reinforcement it is better to put it on the inside of the joint (A) for the outer shell and on the outside joint (B) for the inner shell. Dovetailing and comb joints make strong lightweight joints, but need a machine to cut them.

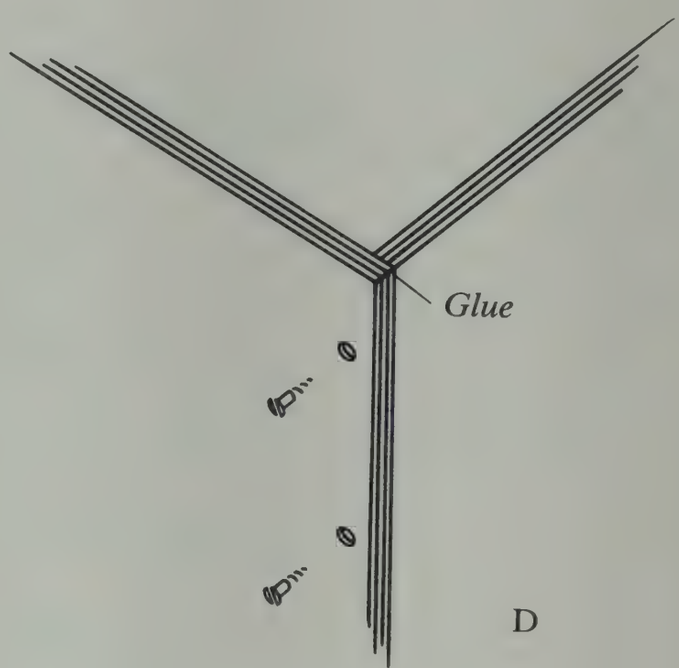
Joints with metal reinforcements

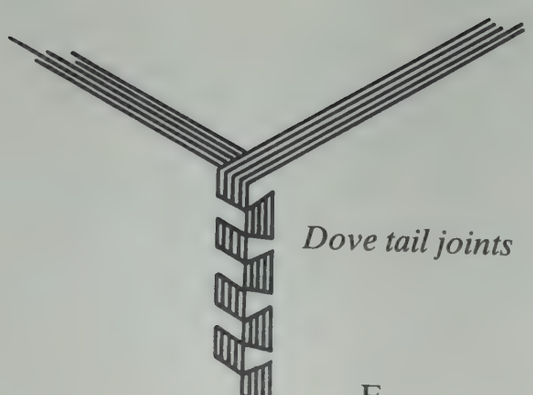


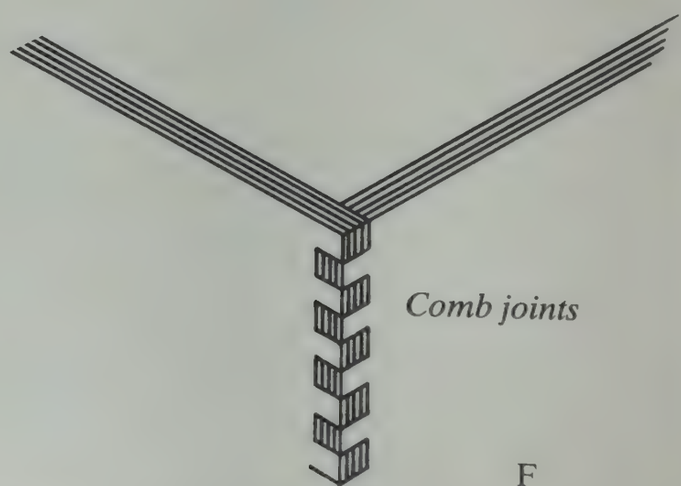


Joints without metal reinforcements

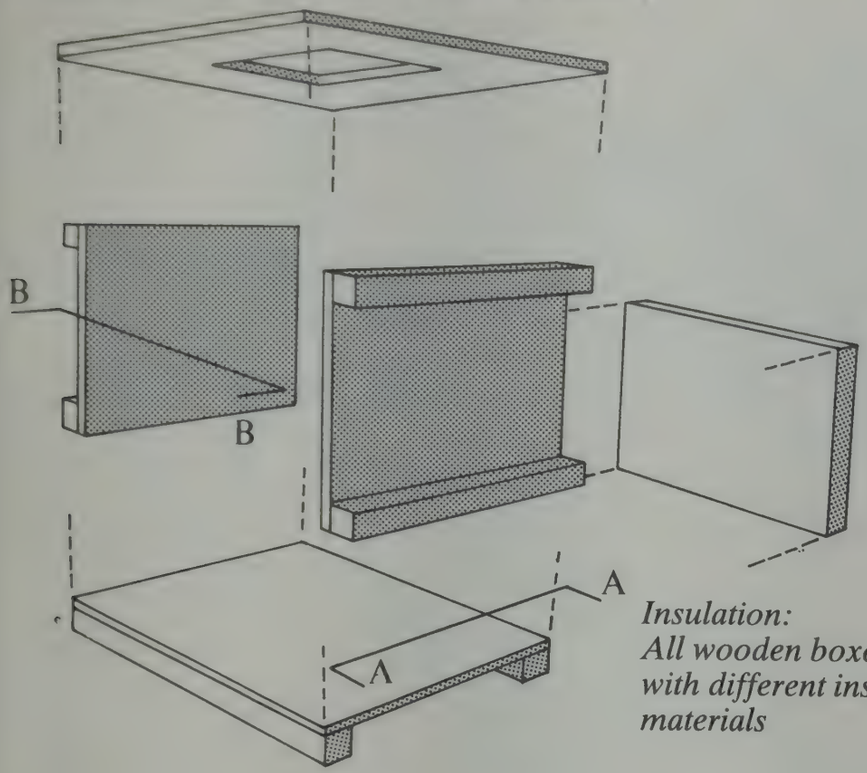






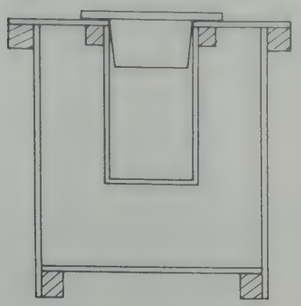


Wooden cold box ready for assembly

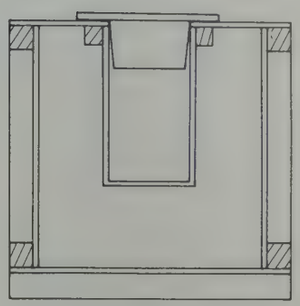


Insulation:
All wooden boxes can be insulated with different insulation materials

Outside casing in plywood with external wooden frame



Section A – A

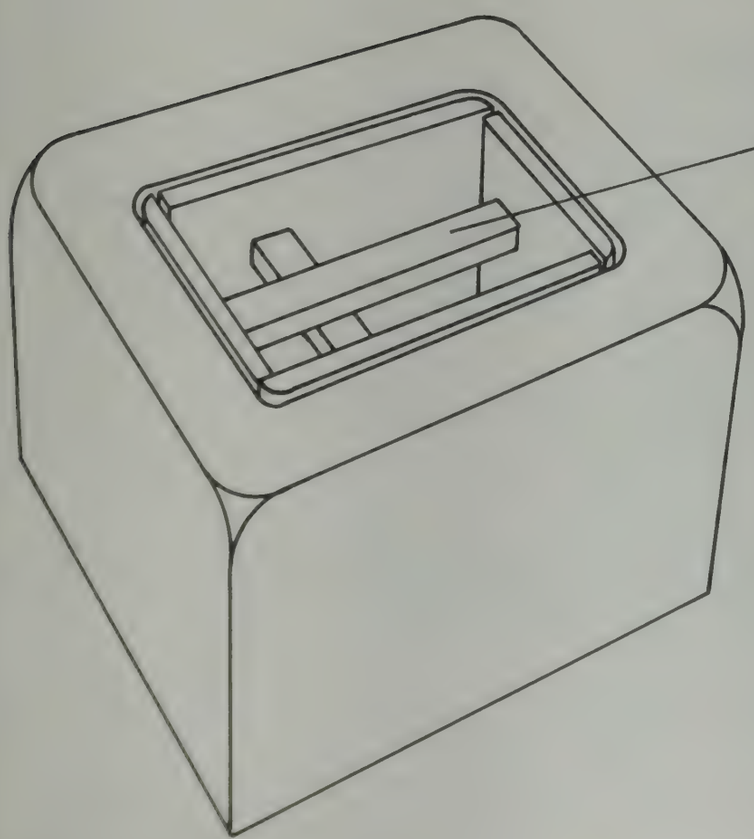


Section B – B

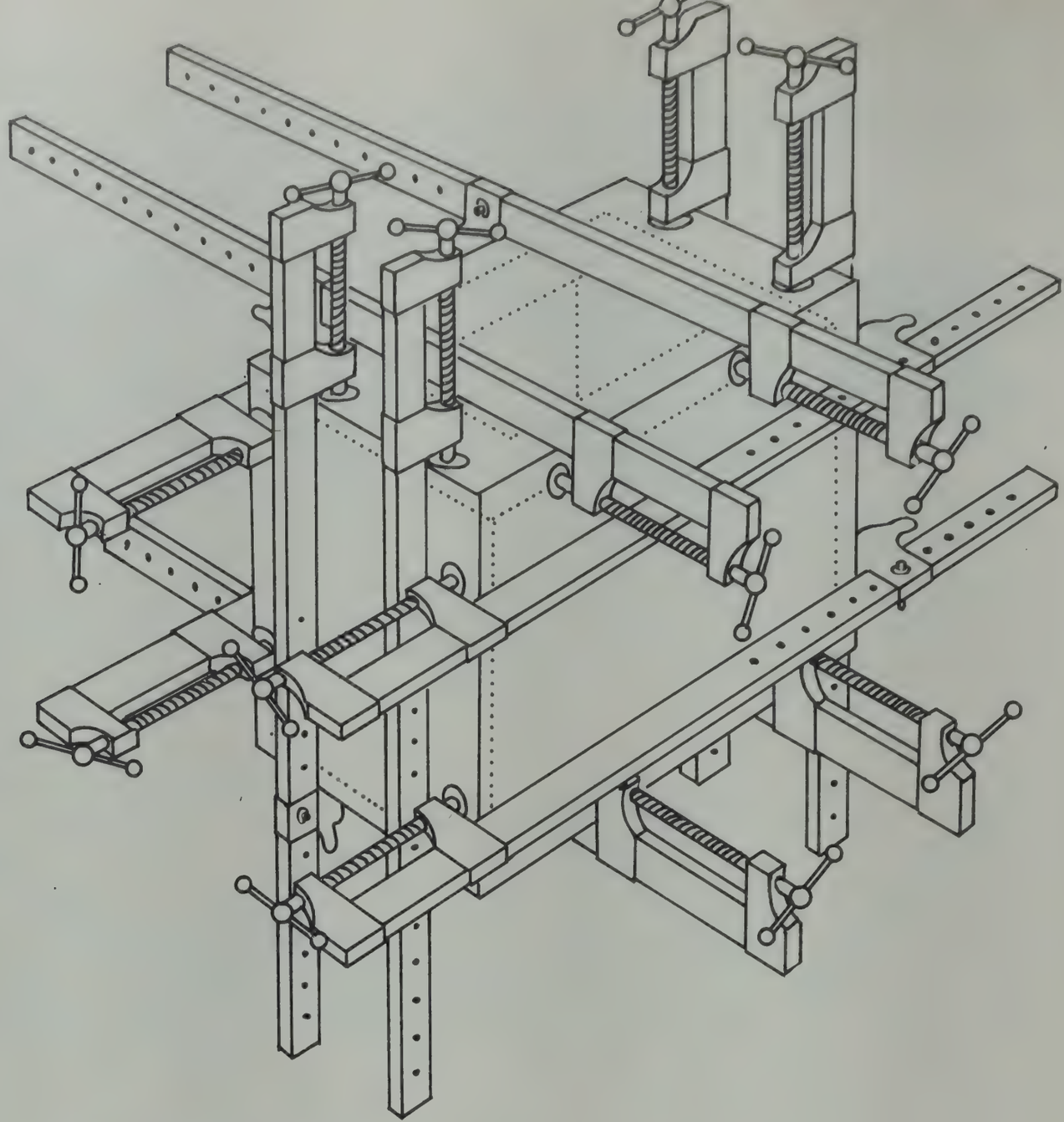
Insulation

○ Using foam insulation

When you inject or pour liquid foam into the cavity in a cold box it puts a high pressure on the shell. If you do not strengthen the shell, it will probably twist and spoil the box. To avoid this, the box needs some extra strengthening while the foam insulation is setting. This is especially important with plastic boxes.

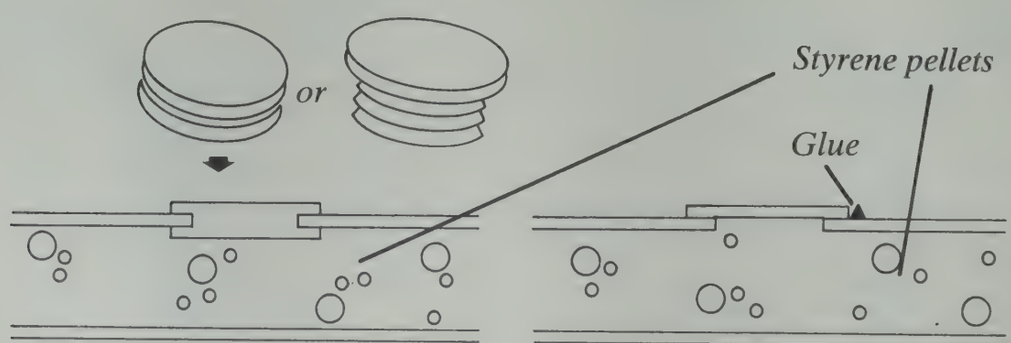


Temporary timber strengthening



External timber strengthening held by clamps

It is essential to mix the correct amount of the chemicals for the volume you want to fill. The manufacturer of the chemicals will show how much you need. If you put too much into the space, the insulation will be too dense and the box may explode. If you put too little, it will not fill the space and will be less effective. Do not smoke while you are using foam. To insert the foam drill a small 50 mm diameter hole in the outer shell of the completed box. Then pour in the liquid in the correct amount and close the hole with a plastic or rubber cap.
Strengthen the box before pouring or injecting foam insulation.
You may use insulations other than foam, but they are less effective. Calculate the thickness using the formulae shown in Annex IV.

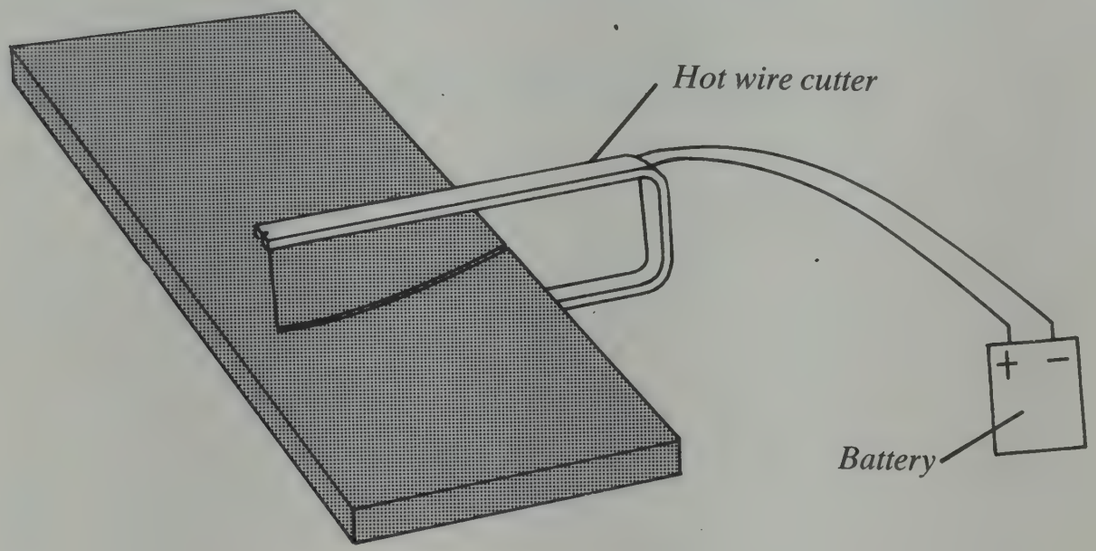


○ Fibrous insulation

You can use many fibrous materials, for example wool, grass, kapoc, cotton, glass fibre wool and rock wool. If you do use these, make sure they are completely dry. Then pack them into the insulation space so that there are no gaps left. But do not crush it or it will be too tightly packed and will not work so well.

○ Sheet insulation

Both polyurethane and polystyrene are available in sheets. They may be cut with a knife or a hot wire cutter. When the sheets are fitted the joints must be tight and the sheets must fill the space available. At the corners the joints should be overlapped.



○ Granular insulation

You may be able to get scrap polystyrene granules which are widely used as packing.

Whichever insulation you use, the outside and inside surfaces of the cold box must be smooth, shiny and light-coloured. This gives you the ~~best insulation~~ against radiation.

You should discuss all these points about insulation very carefully with the manufacturer and make sure he understands them.

Making a contract

When you find a suitable manufacturer, you will need to have an agreement with him to make the cold boxes.

Your agreement or contract with the manufacturer may be simple or complicated. It depends on the size and complications of your order. Nevertheless make the following clear:

1. The product he is to make, with the specification and the number you want.

2. Responsibility: if he is employing a subcontractor for a part of the work, the subcontractor should be responsible to your manufacturer, not to you.

3. Prototype failure: agree a solution with the manufacturer if the prototype fails its test.

4. F.O.B. price: if you are purchasing from abroad, the manufacturer may quote a price F.O.B. This stands for Free On Board. It means the price only includes the cost of putting the product onto a vessel ready for export. You have to add the cost of bringing the product to your country. This includes the cost of freight, insurance, customs clearance and transport from the docks to your site.
Or you can have a price "C.I.F." (Cost, Insurance and Freight) which includes all costs of bringing the goods to a port in your country. It does not include customs charges on the cost of inland freight.

5. A timetable: ie. the dates for completion of the design, production of the prototype, testing of the prototype and production and delivery of the main order.

6. Place of delivery: you may make the manufacturer responsible for delivery to your address. In this case he needs to include the cost of carriage and insurance in his price. You may collect the finished cold boxes from his factory, which may be cheaper for you.

7. The price: separate the cost of producing a prototype from the unit cost of the product, the unit cost should reduce for a large order.

8. The method of payment: the manufacturer may ask for part of the cost to be paid before starting work, and for payment by instalment during production. Always arrange payments so that you owe him money (after the first payment) for the rest of the agreement. Keep a part of the cost, say 10%, until you are satisfied that the cold boxes really are according to your specifications. A manufacturer will be much more helpful, if you still have some of his money.
One way to set payment is to fix it to the stages of the time table, for example: Part payment at design completion, production of the prototype, satisfactory testing of the prototype.

9. Quality control: agree with the manufacturer a system for quality control, using the following guide. You can vary or even omit some steps in the guide, if the manufacturer constantly produces a good quality.

- Ask the manufacturer to produce and give you one box at the beginning of the production. That can serve as a quality standard for all the other boxes.
- Agree with the manufacturer that you (or somebody named by you) can visit the factory without warning to see the manufacture in progress.
- Decide how often you should test the cold life, durability and leakage of a box taken off the 'production line'. Probably one box every 2–3 days is a suitable number.
- Select boxes now and again for testing yourself. Do not accept boxes given over by the manufacturer for testing.
- If one of the sample boxes fails any of the tests, discuss the problem with the manufacturer. Do this to stop the delivery of any other boxes below standard and to find the problem in production.
- Make an agreement to carry out tests after 6–12 months.

10. Disagreements: if you and the manufacturer cannot agree, you must have a third party whose decision is binding.

11. Termination: decide the terms for either party not completing the agreement.

Section 6

How to make your own cold box from wood

You may not find a manufacturer to make you a cold box. In which case you may have to make your own. This section explains how to do this and gives you some ideas to work with.

Step 1: Decide the size and shape

Do this according to the methods described in sections 1 and 5.

Step 2: Choose your material

In all probability you will use wood because it is common. Make sure you have enough material and accessories.

Tools you will need will include:

- Tenon saw
- Cross cut saw
- Hack saw
- Hand drill
- Drill bits and countersink
- Centre punch
- Plane
- Wood worker clamps
- Rule
- Try square
- Scriber
- Chisel
- Screwdriver
- Hammer
- Pliers
- Pincers
- Awl
- Sand paper
- Paint brush
- Glue
- Screws
- Panel pins

Accessories you need:

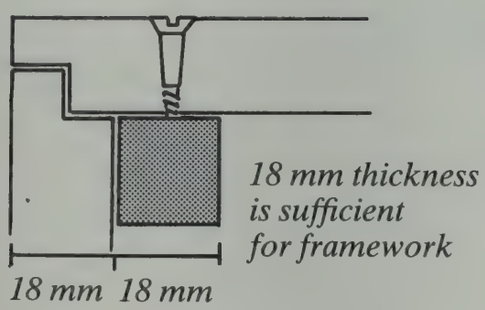
- Hinges
- Catches
- Lock
- Handles
- Lid stay
- Lid seal

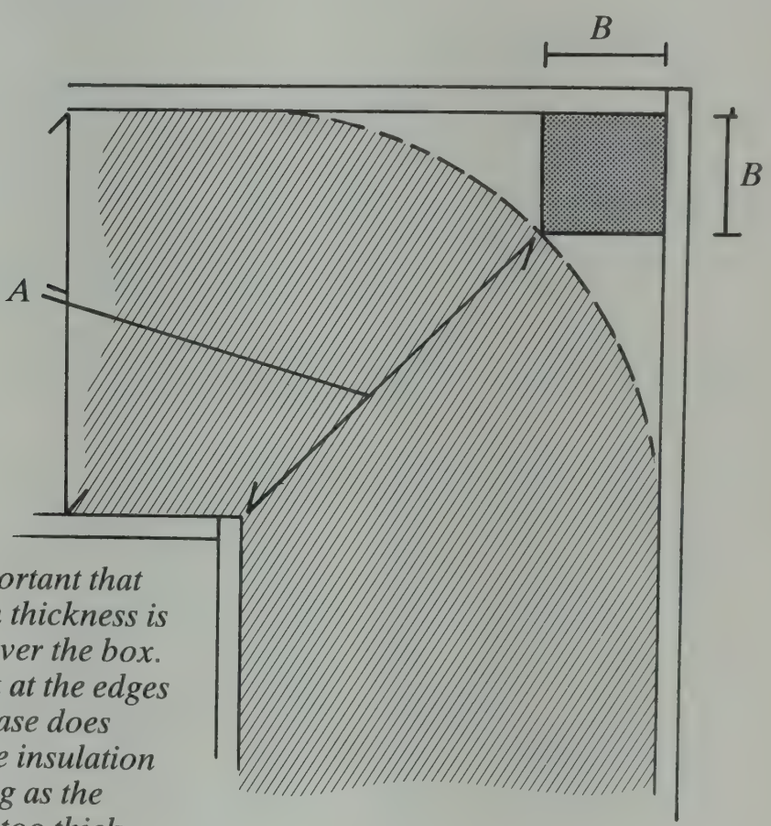
Step 3: Make a design

Keep these points in mind when you design a cold box:

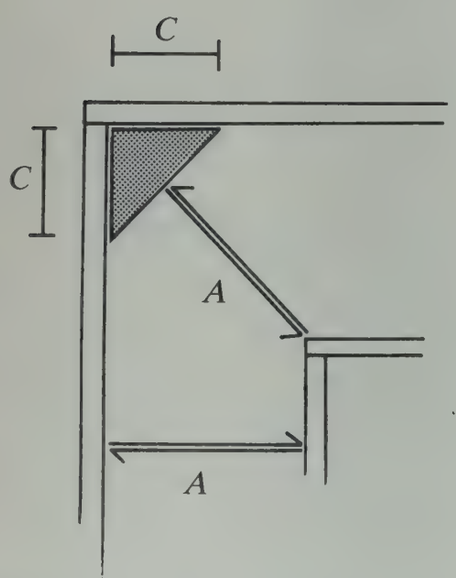
- The surface area should be as small as practically possible, i.e. as near a cube as possible. A cylindrical shape is useful for small containers, but is bad for ice packs. A tall, narrow, rectangular shape is good for containers to be carried on the back.
- The lid should be as small as practical.
- The handles must be above the centre of gravity when the box is full.
- The inside dimensions must fit the ice packs which you have or can buy. If the dimensions do not fit there will be gaps between the ice packs which reduce the cold life.
- The inner lining must be impervious.
- All joints must be impervious.

Here are some useful calculations to help you decide the size of wood to use.





It is very important that the insulation thickness is constant all over the box. A framework at the edges of the outer case does not reduce the insulation quality as long as the section is not too thick.



When A = Insulation thickness
and B = Thickness of the wooden section

The maximum thickness of the section can be:
$B_{MAX} = A - \frac{1}{2} A \sqrt{2}$

Example 1: $A = 100$ mm
$B = 100–50 \sqrt{2}$
$B = 30$ mm
This size is more than sufficient to construct a framework

Example 2: $A = 60$ mm
$B = 60–30 = \sqrt{2}$
$B_{MAX} = 18$ mm

If the insulation thickness is less than 60 mm, then a framework with triangular intersection can be used.
Size of the framework is C.
$C_{MAX} = 2A - A \sqrt{2}$ $(C_{MAX} = 2B_{MAX})$

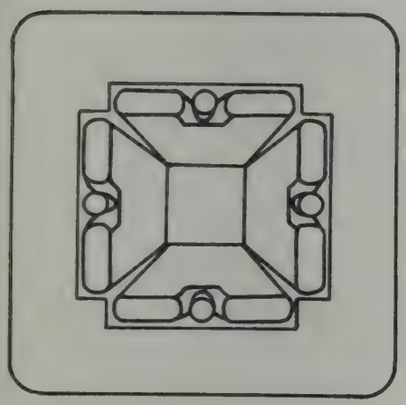
Example 3: $A = 40$ mm
$C_{MAX} = 24$ mm

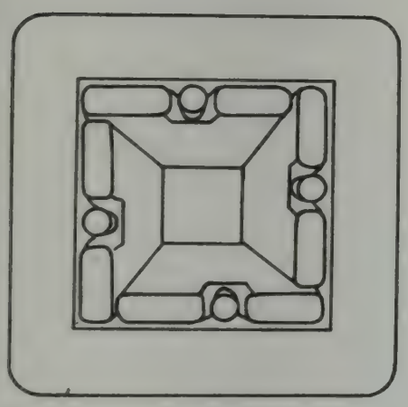
Design the inner shell first, then design the outer shell and the lid. Here are some ideas on how to arrange your ice packs. Try arranging the ice packs like this. Then measure "A", "B" and "C" to decide the inside dimensions. Remember ice packs increase in size when they freeze. Check to see if this will change your dimension. If you squeeze the ice pack slightly before sealing it, this will help minimize the distortion (see page 51).

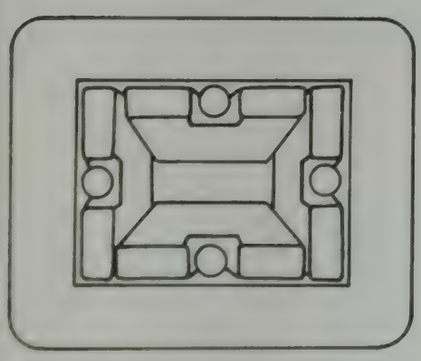
It is important to position the ice packs in such a way that they remain stable during transportation and do not fall into the space for the vaccine.

Here is a simple solution (see page 25):
A metal basket, which gives just enough space between the inside walls and the basket to insert the ice packs.

Different arrangements of ice packs



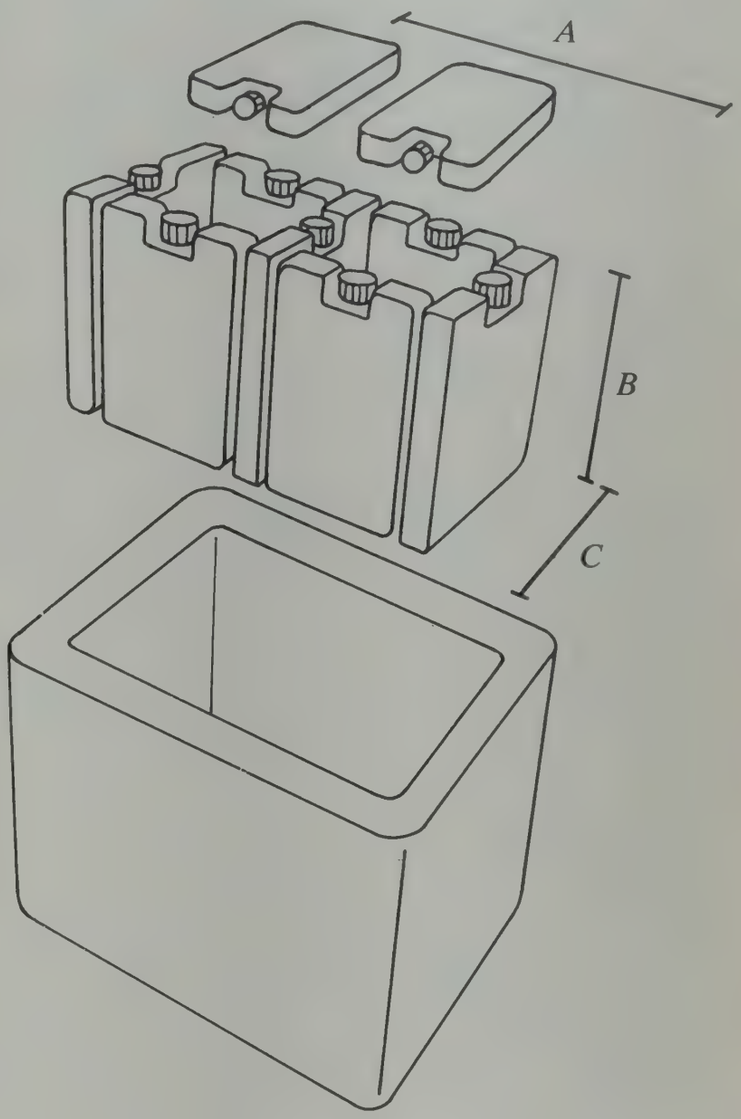


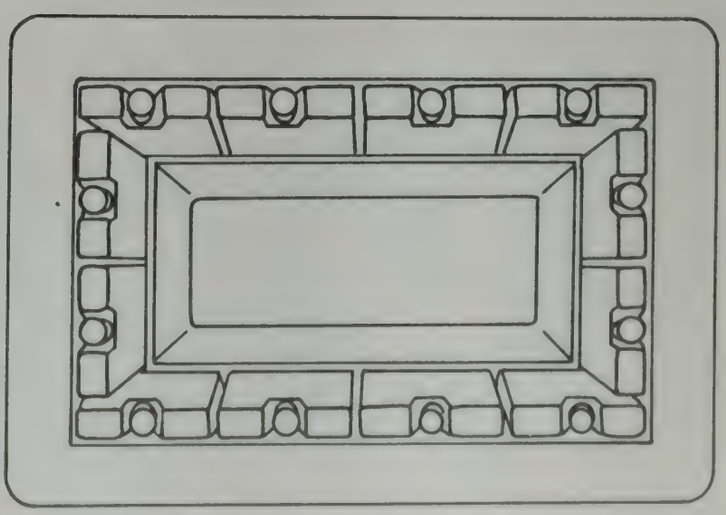


In small vaccine carriers: cold packs can be pushed in place tight together.

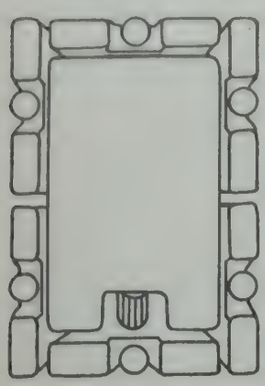
Vaccine carriers for 2 or more days can be designed with separate vaccine compartments so that the vaccines to be used last are not so affected by heat convection or radiation.

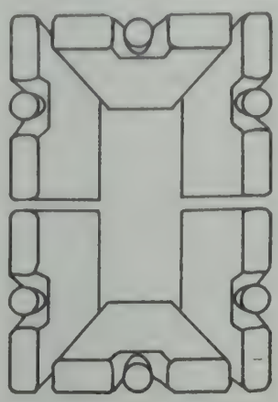
These separate compartments can be built up by the ice packs.

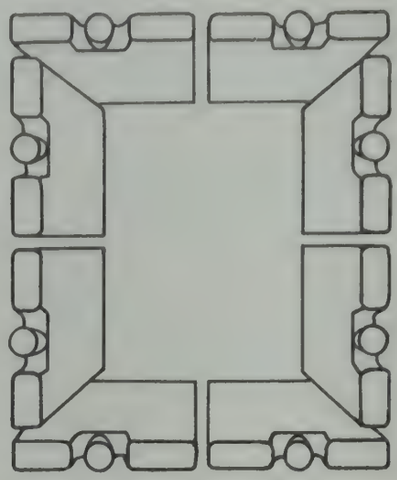


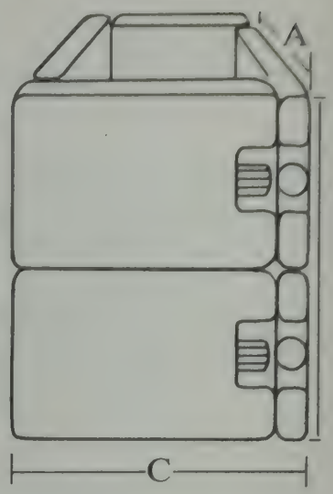


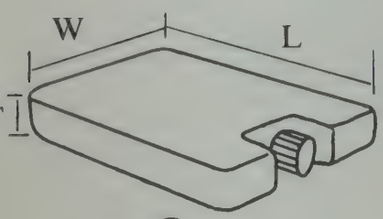
Building up the internal storage volume for the vaccine.
Many arrangements are possible depending on the required volume and shape.

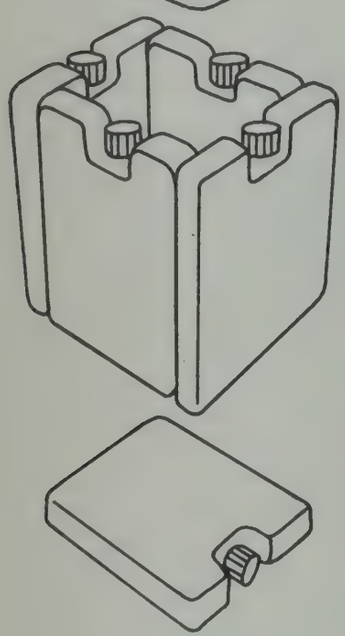








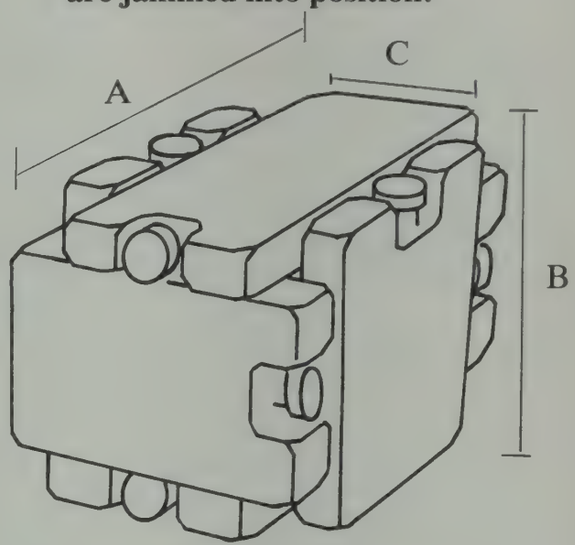




When cold packs are required on the top as well as at the bottom of the vaccine carrier, cold packs of specific dimensions are also needed since length, width and thickness are then critically related.

Length (L) = Width (W) + 2 thicknesses (T).

Cold packs can also be so placed in the cold box that the packs are jammed into position.



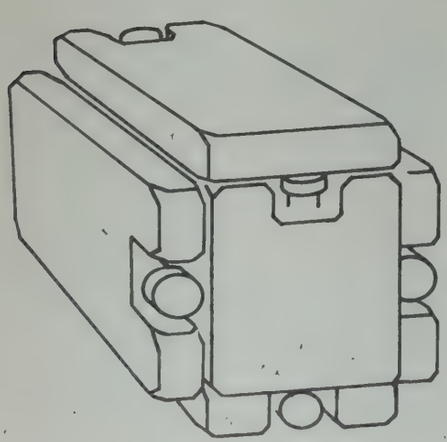
Length = width + 2 thicknesses
6 ice packs

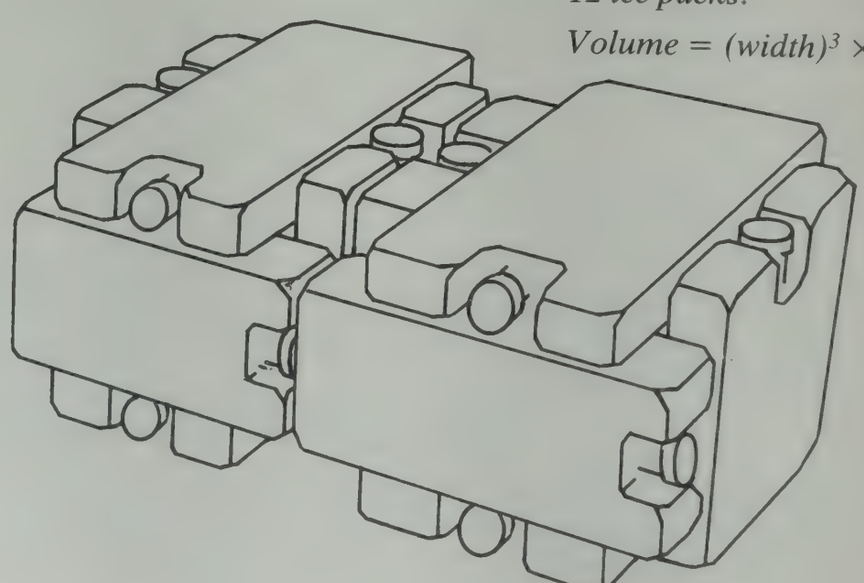
Volume = (width)^3

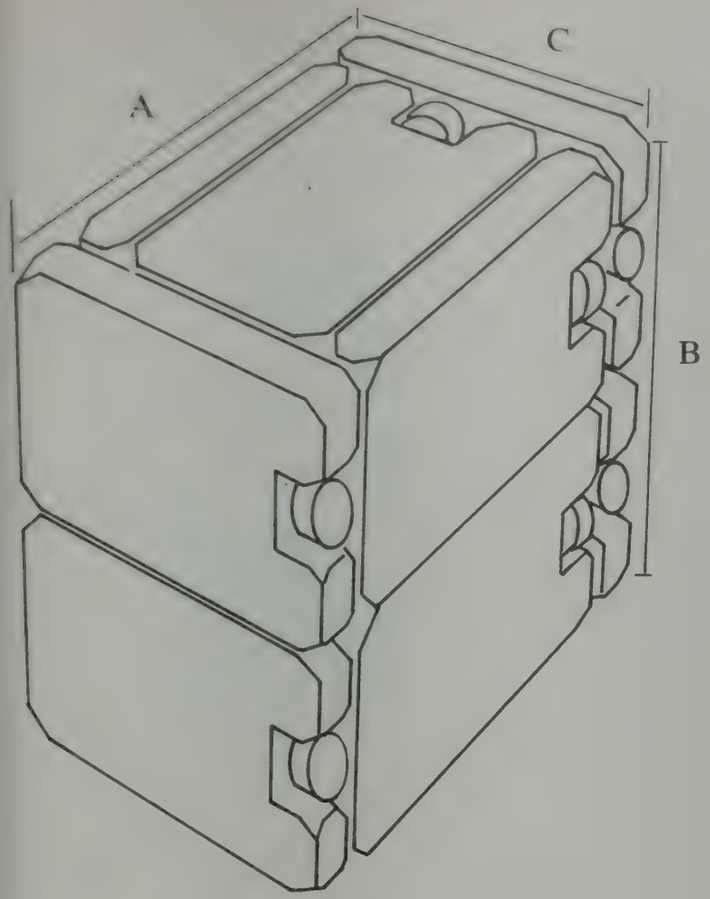
Double container
12 ice packs.

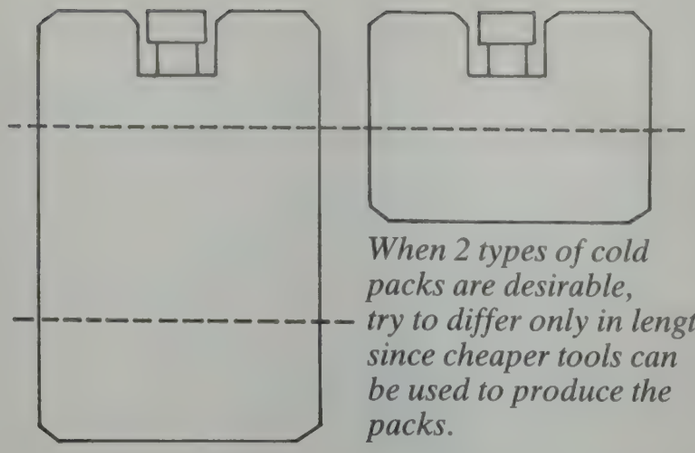
Volume = (width)^3 × 2

These types of cold packs are in production.







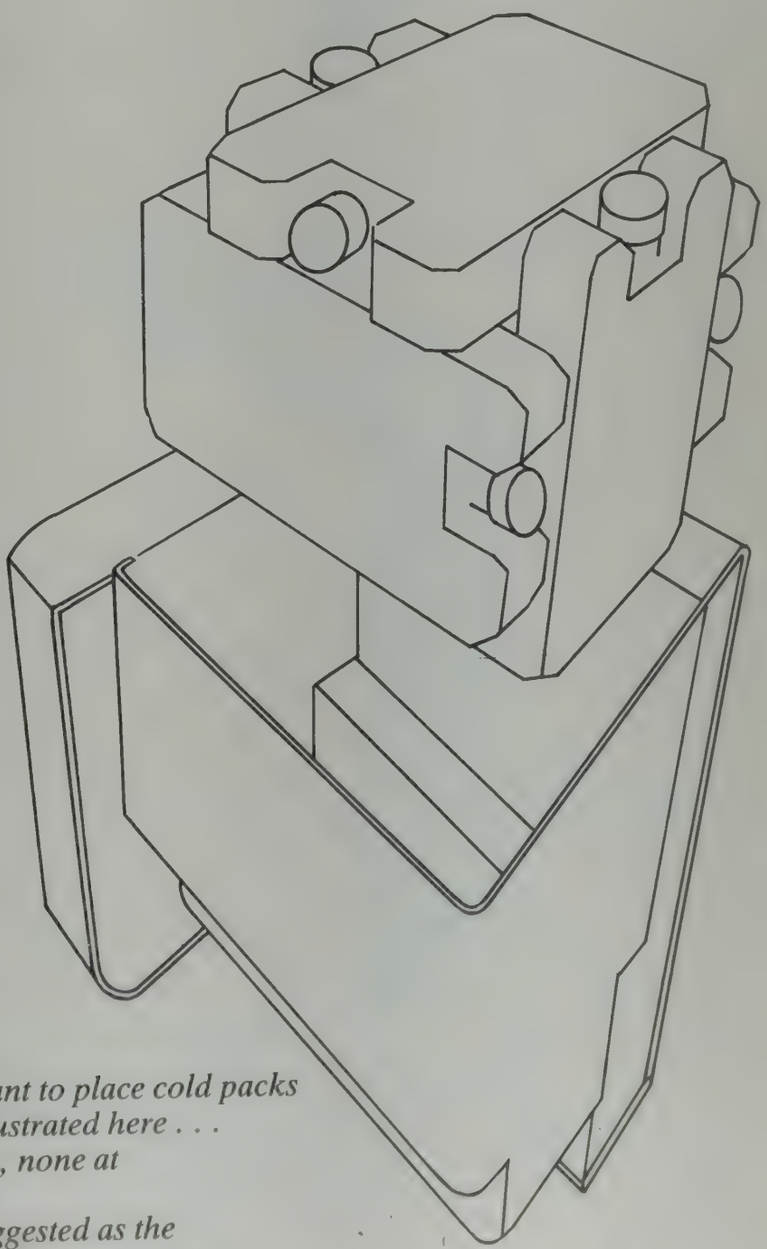


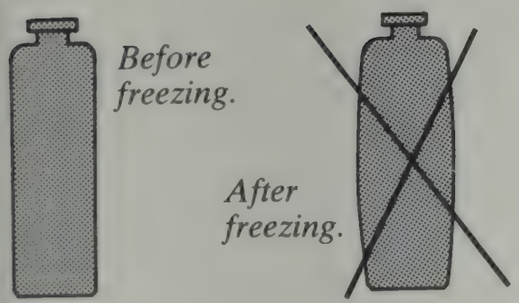
When 2 types of cold packs are desirable, try to differ only in length since cheaper tools can be used to produce the packs.

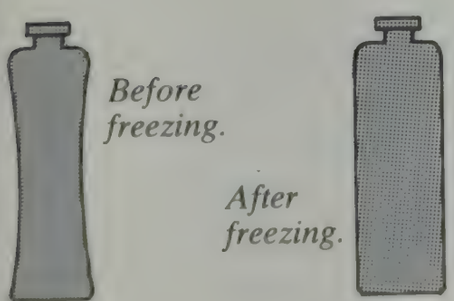
It is geometrically simple to produce the middle section of the cold pack whereas the mould for top and bottom can be common to both sizes.

Length = width + 2 thicknesses.

When the cold packs have the above specifications it is possible to build up the height with two cold packs stacked horizontally.





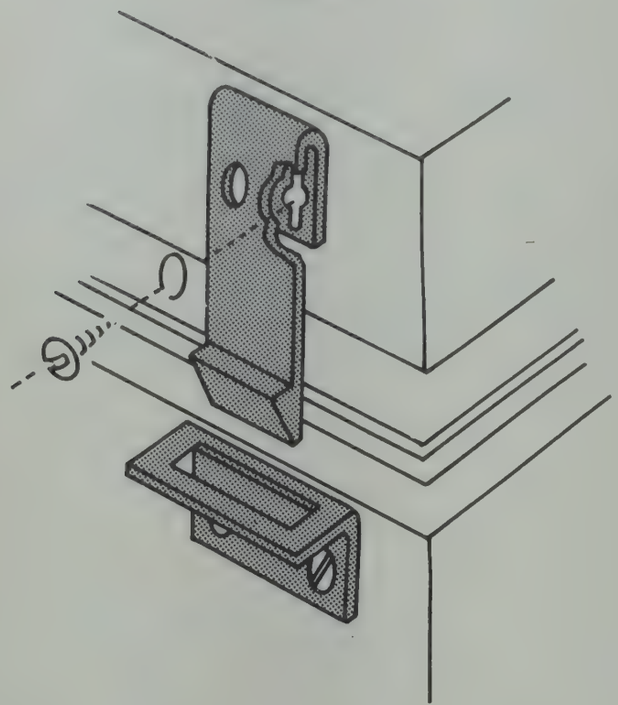


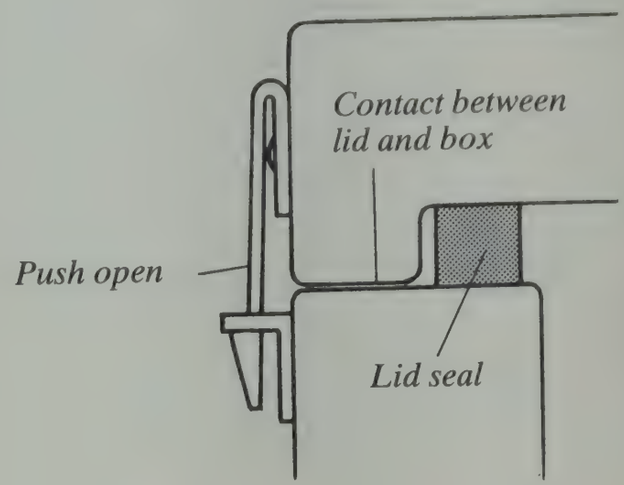
When you want to place cold packs in the way illustrated here . . . (5 cold packs, none at the bottom) . . . this is suggested as the shape of the inside container.

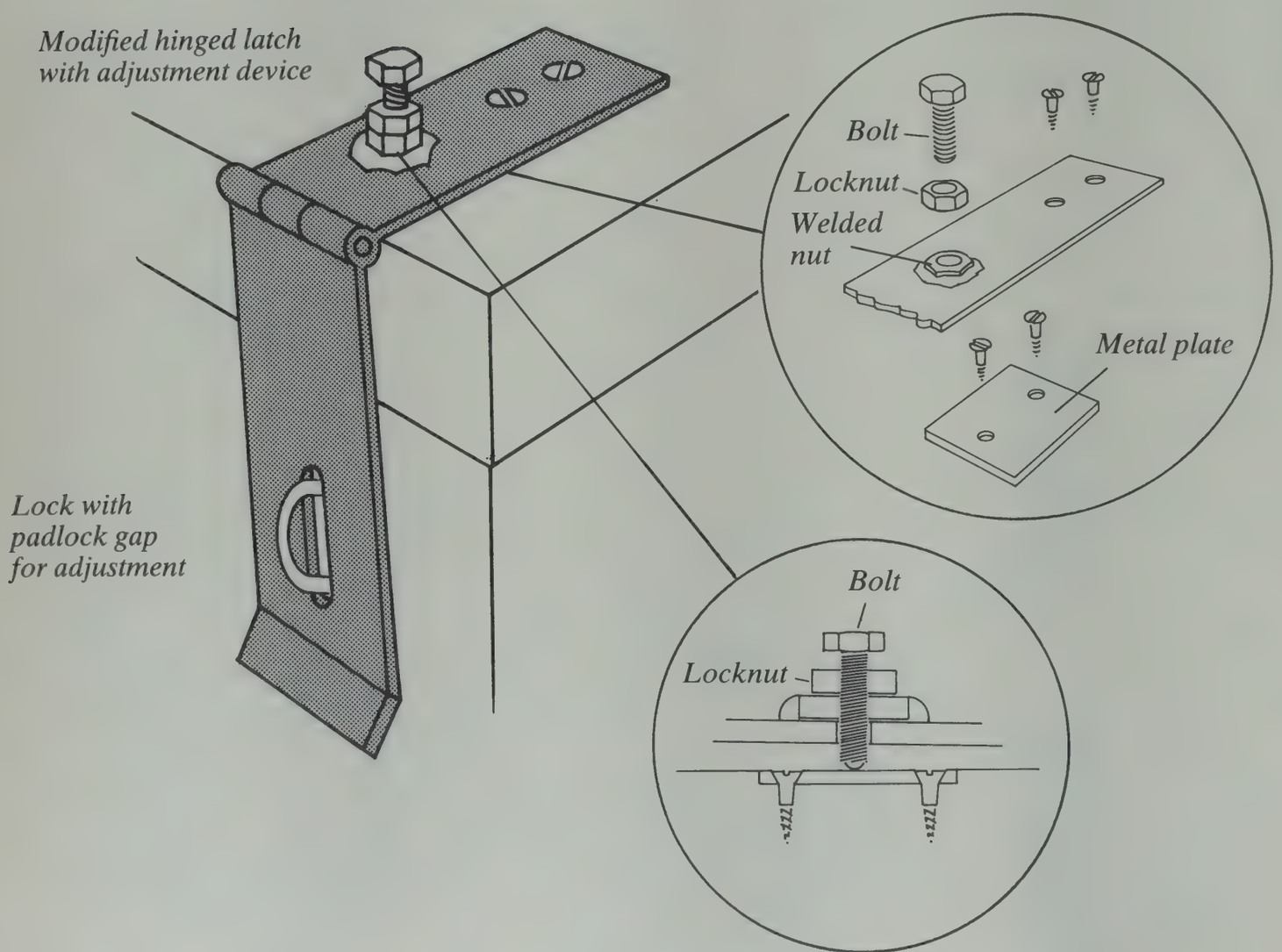
Step 4: Fix accessories

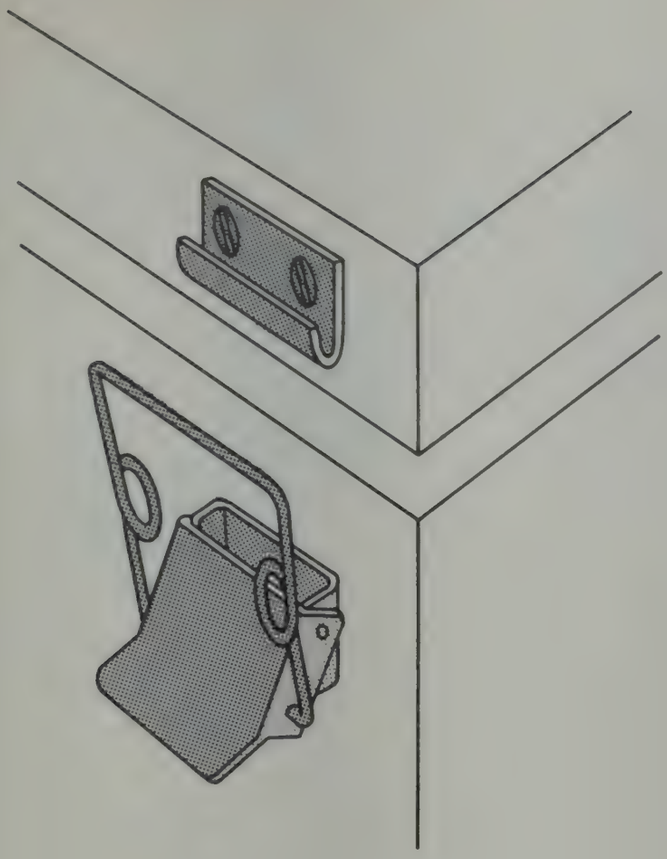
If you cannot buy catches or handles you can have them made. Or you can make some yourself, using the following diagrams:

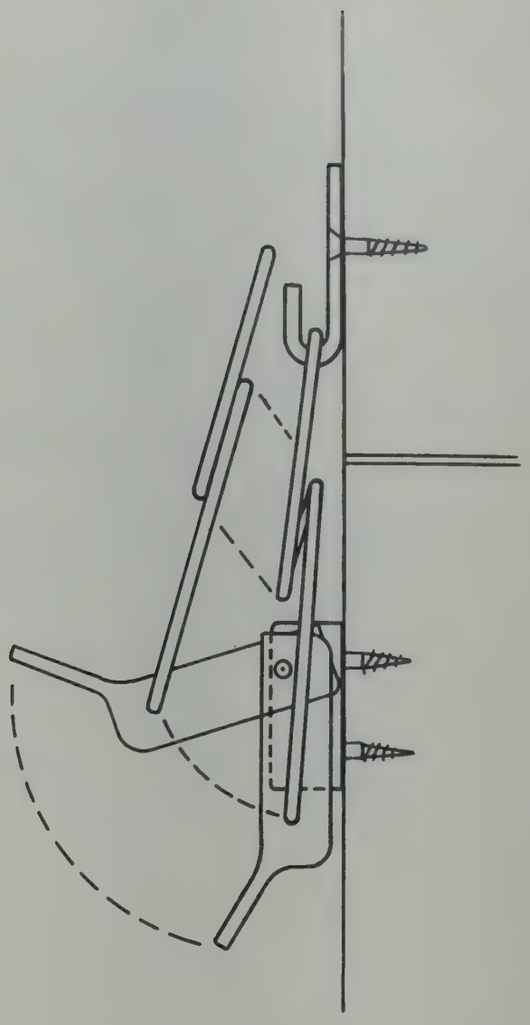
Catches



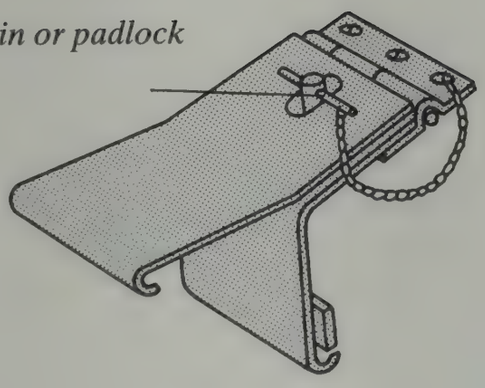


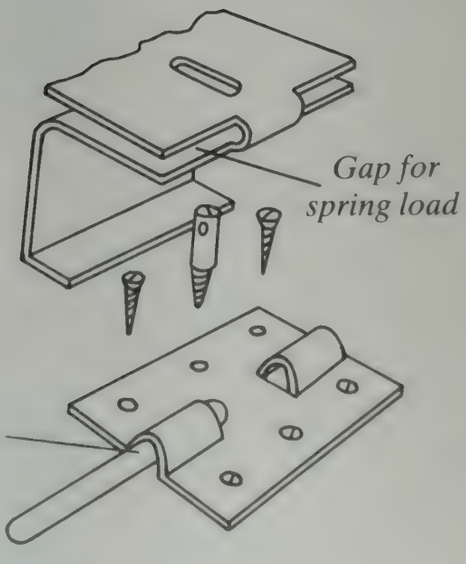




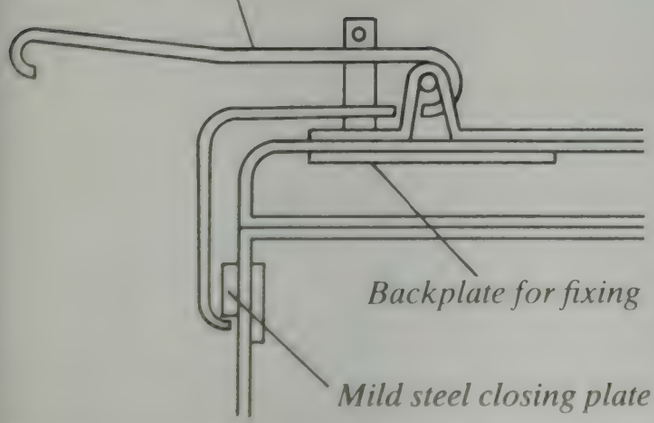


Securing clip pin or padlock

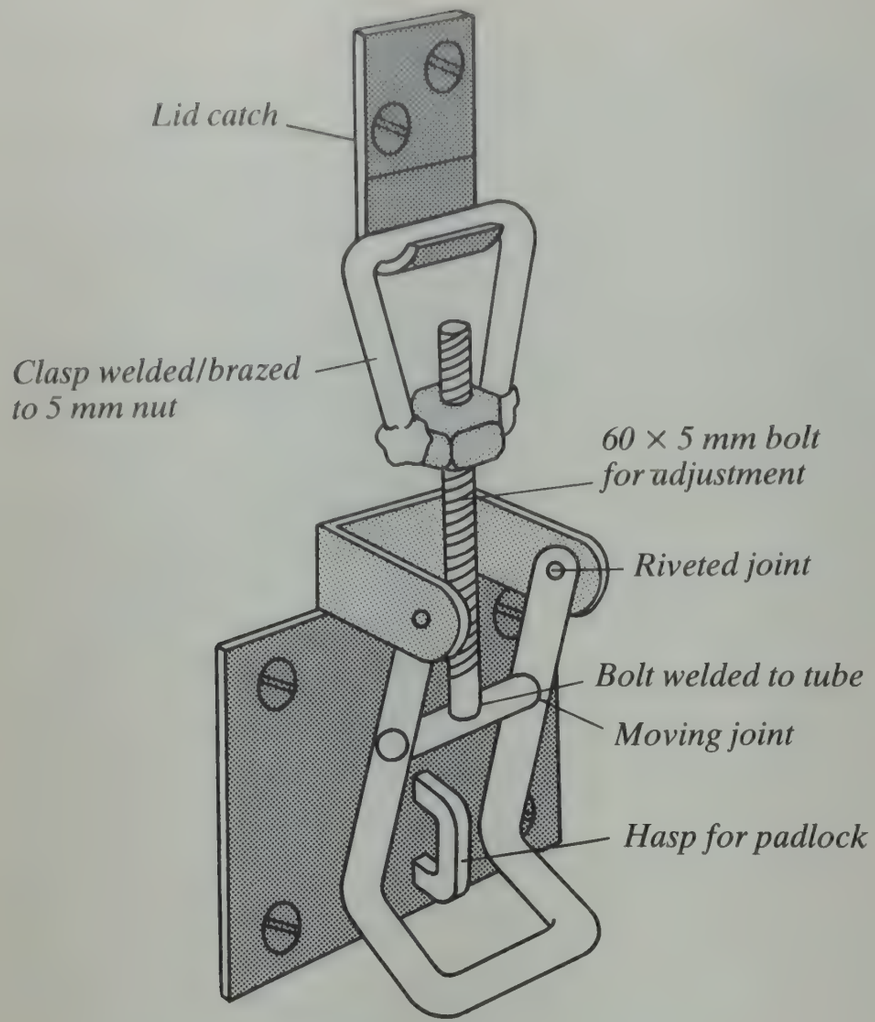


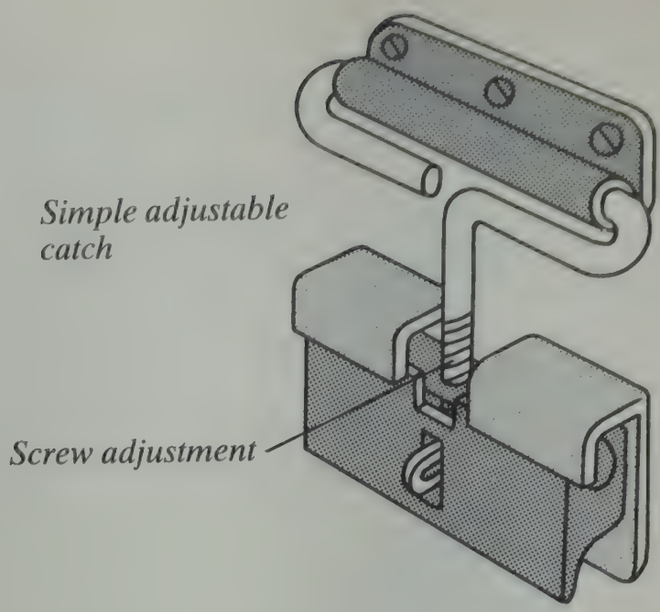


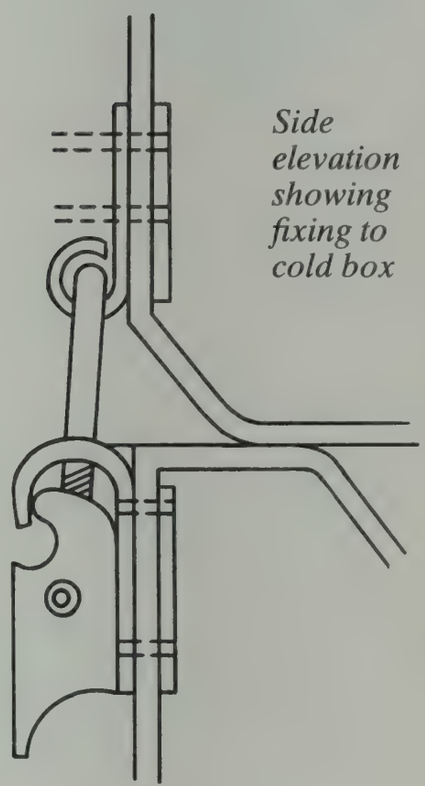
Closing plate



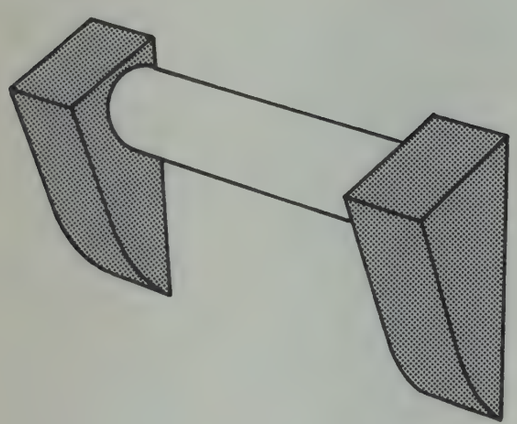
Use available hinge and remove centre section to receive catch



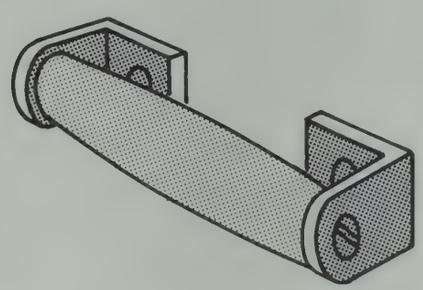




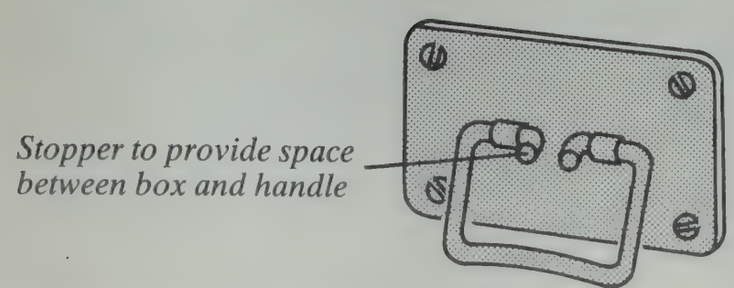
Handles



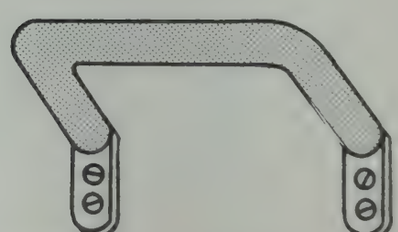
Wooden handles with metal or wooden supports



Hinged handle



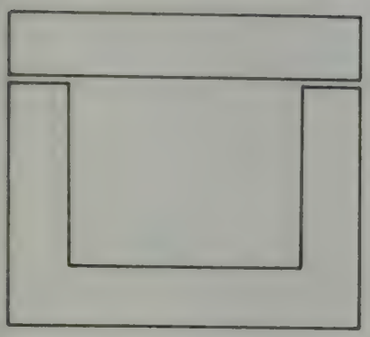
Metal handle



Lid seals

It is most important to design the lid well. If your cold box fails to keep cold it will probably be because the lid does not fit. You have two basic choices:

Lid outside



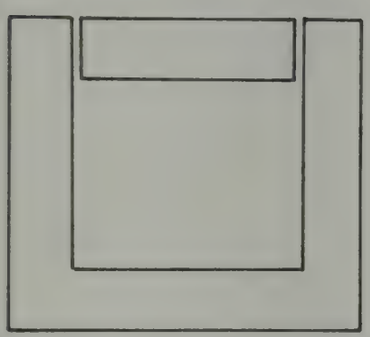
Advantages

- It is easy to make
- Standard catches and hinges can be used

Disadvantages

- It puts pressure on the hinges because the lid is bigger
- You can easily knock the lid and damage it
- It can twist out of line
- It has a longer length of seal

Lid inside



Advantages

- It gives good protection to the lid
- Good lid positioning
- The lid is smaller and lighter
- The seal is better because it is shorter

Disadvantages

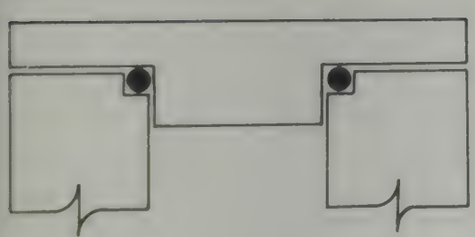
- It is harder to make
- It may need special lid catches and hinges to seal

The pressure on the lid seal must be controlled. This may be in one direction or in two directions. The seal may be single or double and with some plastics you can omit it altogether.

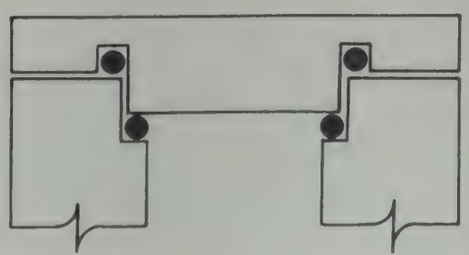
A. **Single seal** (one direction)
The amount of pressure on the seal is controlled vertically.

B. **Double seal** (two directions)
The amount of pressure on the seal is controlled vertically and the lid is located horizontally.

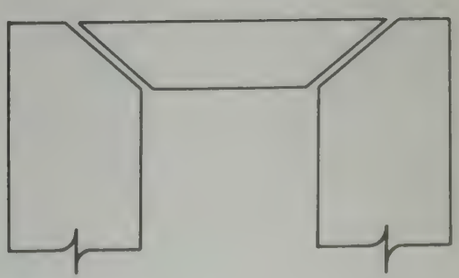
C. **Self sealing lid**
Using polyurethane



A

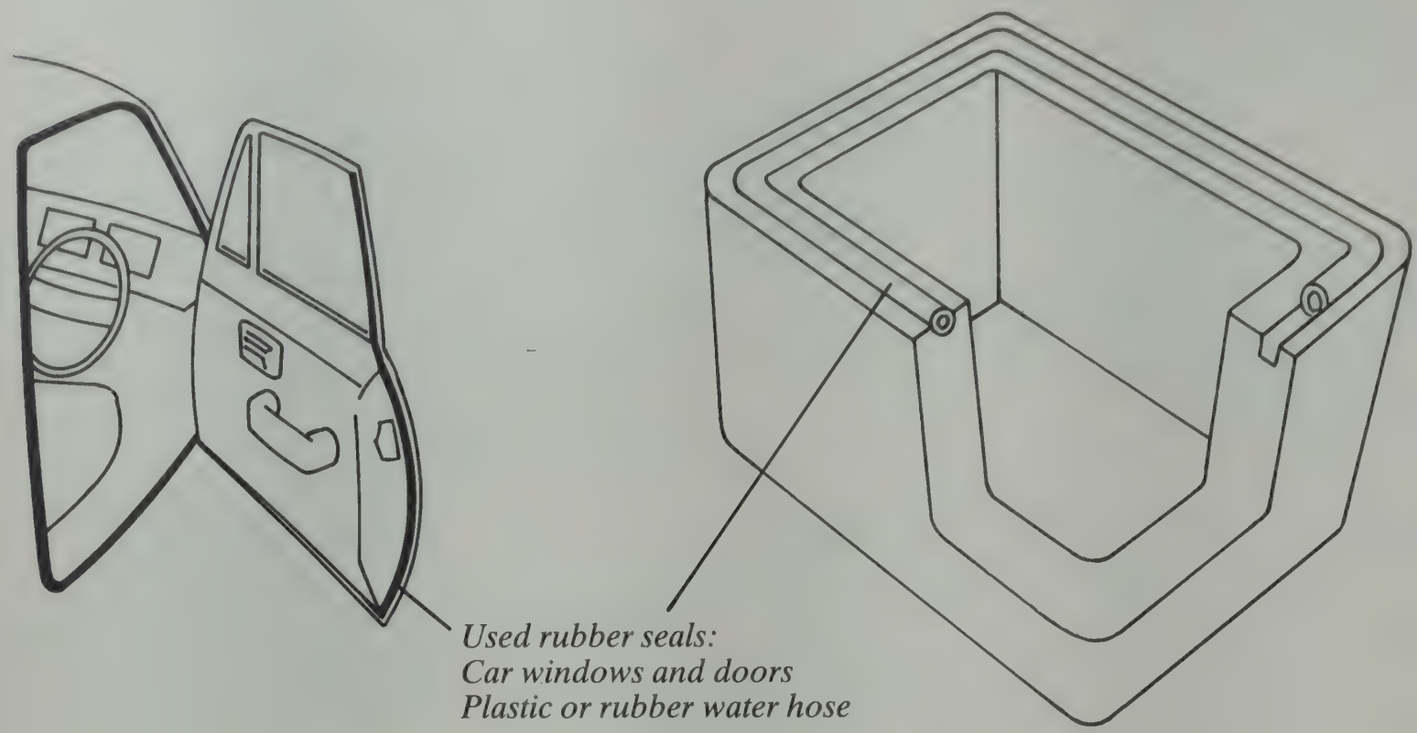


B

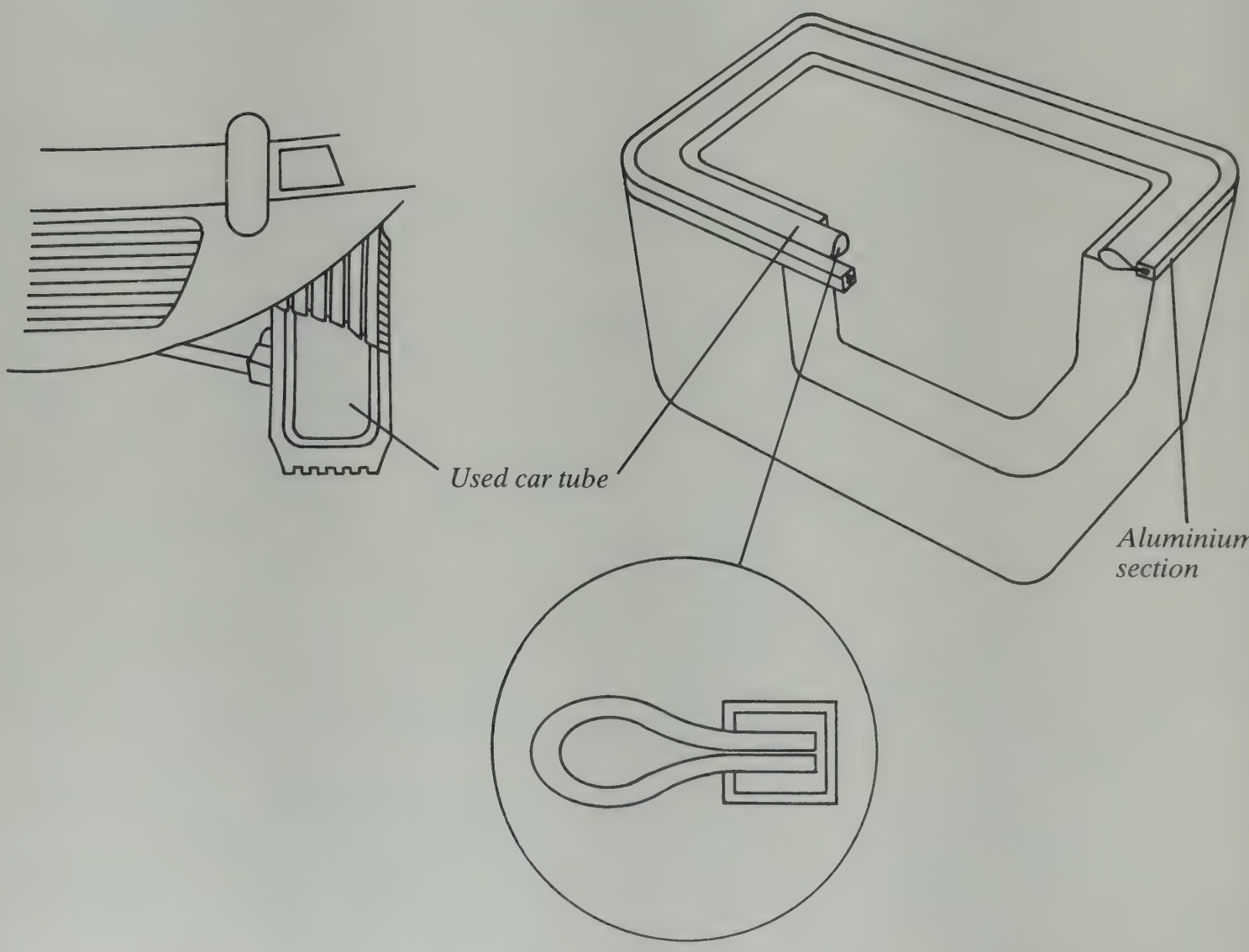


C

The best materials to use are described on page 15. Here are some examples of materials that can be used to make the lid seal.



Used rubber seals:
Car windows and doors
Plastic or rubber water hose

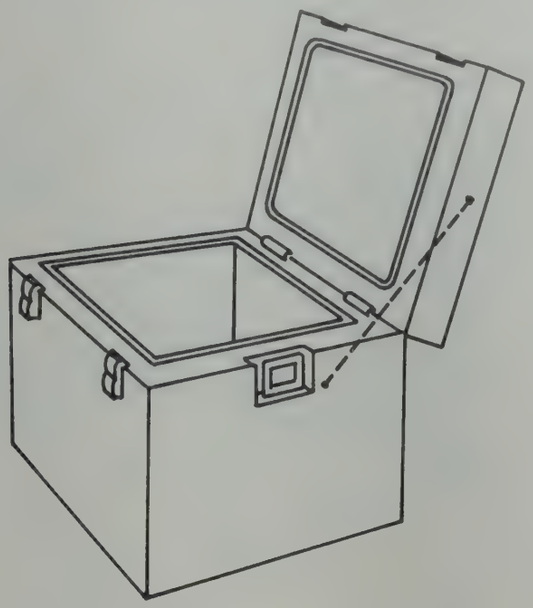


Used car tube

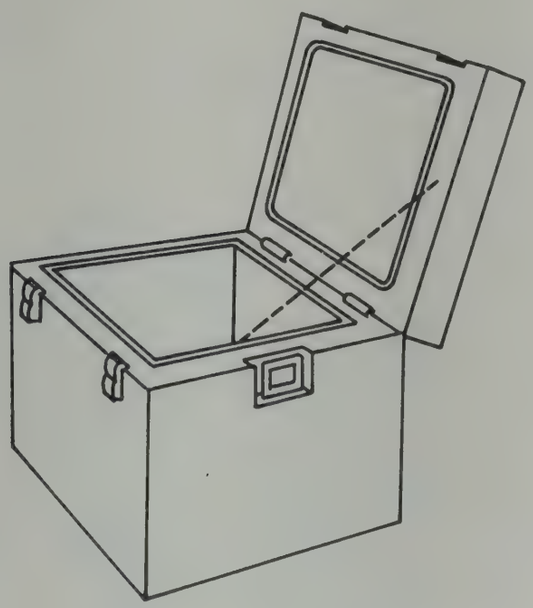
Aluminium section

Lid stay

After fitting a hinged lid, fit a lid stay. You can fit this on the outside, which is easier. But the stay may get in the way, when the lid is closed.

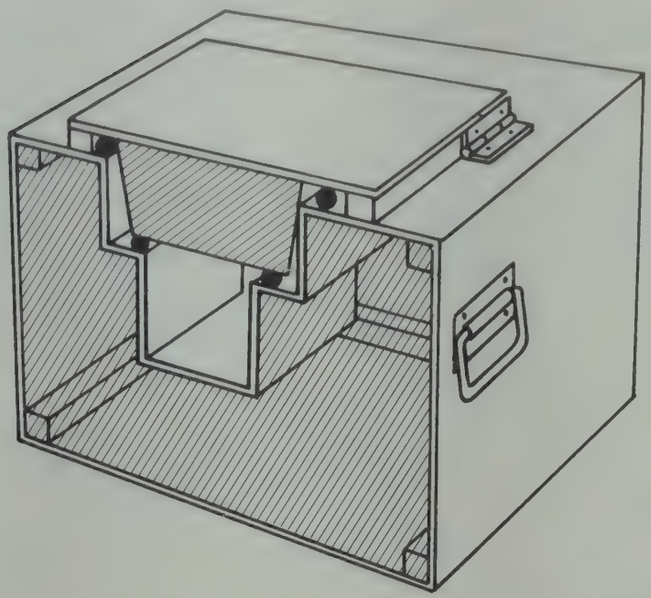


Or you can fit it on the inside which is neater when the lid is closed. It needs careful fitting, however, to make sure the fixing points are vapour proof.



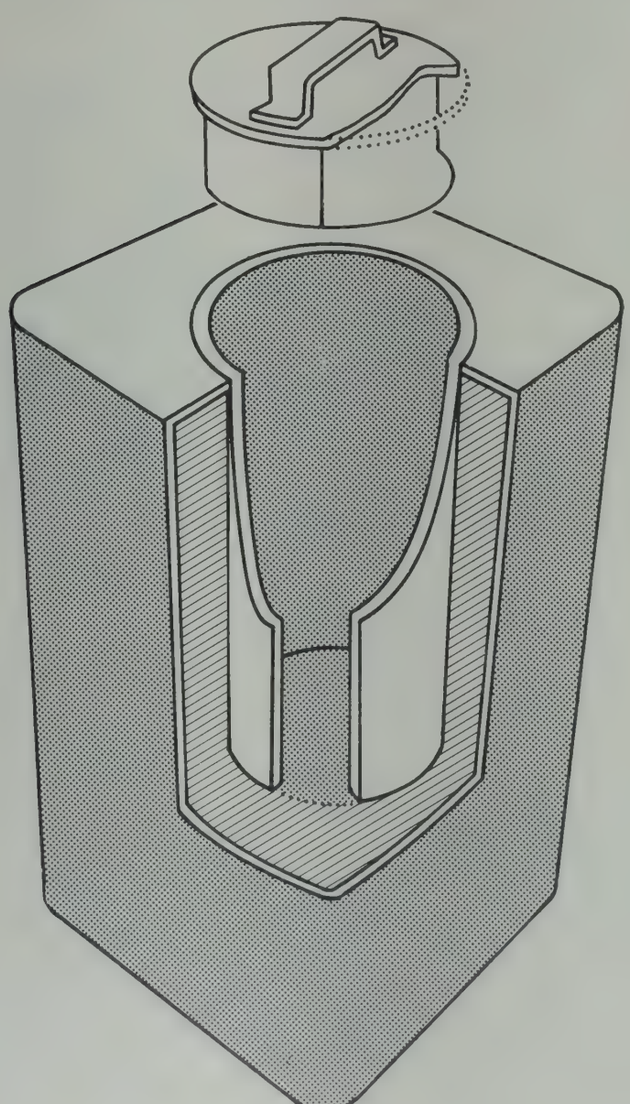
A simple cold box

Note: The double lid seal.
The thick insulation in the sides and lid.
The cold box is painted white outside.

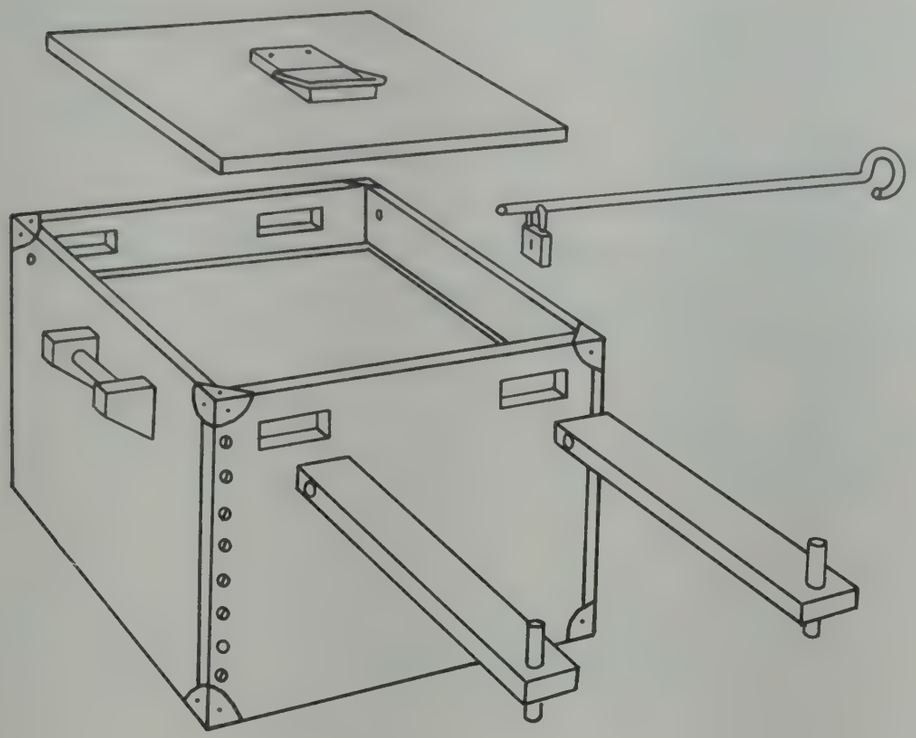


Two simple ways to make a cold box:

1. Take a 4 gallon kerosene can. Hang a smaller cylindrical can inside it. Then fill the cavity with insulation. Make sure you seal the top.

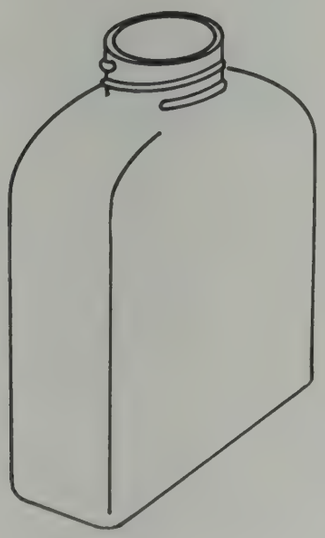


2. Take a large vaccine shipping container and make a very strong box for it. The following diagram shows you how to do this very simply. The best container, is made by Savopak Oy of Finland (see Annex II).



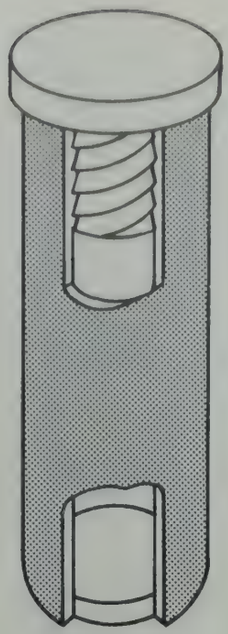
Make an ice pack

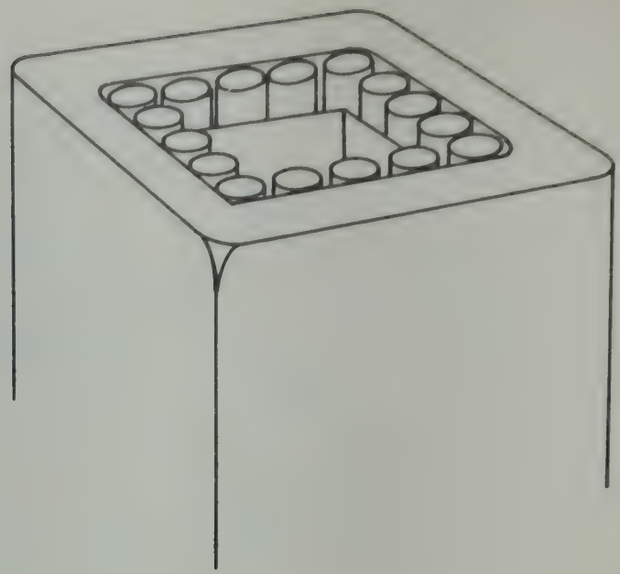
If you cannot find any ice packs, you can make your own from any plastic bottles. Try to get rectangular ones, all the same size.



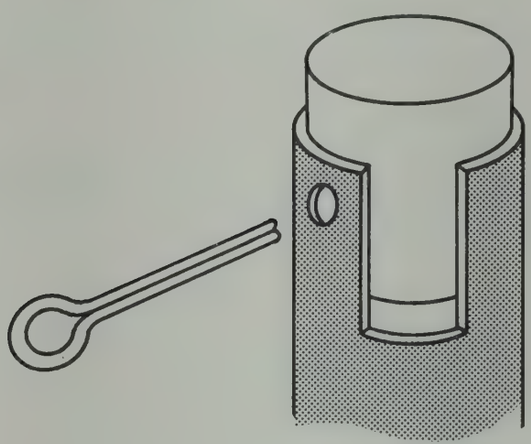
Alternatively, freeze water in plastic bags inside a cardboard box of appropriate dimensions. Make sure you seal the bags carefully. When they are frozen the ice packs can be removed and stored in the freezer, while the boxes are used to make more ice packs.

You can also use PVC tubing. This you can cut to the length you want. Then glue a plug into the bottom and have a coarse thread cut on the top to take a screw.





Another way to seal the tubes is to fit both ends with a long cork. You can fasten these by putting split pins through them. Make sure you leave at least 4 cm empty at the top after filling to allow the water to expand when it freezes.



Section 7

How to test a locally made cold box

This section tells you how to test your cold box to make sure it will keep your vaccines safely.

When your manufacturer prepares his prototype, you need to test it. Before you carry out any testing, show it to the people who will be using it and who you talked to originally. Let them examine it to make sure that the prototype satisfies the design.

The three physical tests you should carry out on a cold box are:

- Measurement of its cold life
- Measurement of its durability
- Leakage test

Using an independent test laboratory

You may wish to test your cold box so that you can compare it with other boxes world-wide. Then send it to an independent testing laboratory.

WHO/EPI
1211 Geneva 27
SWITZERLAND,
can supply the names and addresses of test laboratories.

If you decide to send a cold box for testing, carry out the following:–

Provide a proforma invoice with the following information:–

Description of the prototype (such as cold box, vaccine carrier)

Brand name (if it has one)

Model type (e.g. 20 litre)

Serial Number (if it has one)

Manufacturers full name and address

Number of items sent

Number of packages

Volume and weight of packages

Value of product (in US$ if known)

A clear statement that the product is "For testing purposes only".

Send an advance telex or cable warning the test laboratory when the product is going to arrive. This should contain the following:

Name of receiving laboratory and persons responsible
Number of products
Number of packages
Manufacturer's name
Purpose of sending (such as "For WHO tests")
Date of sending
Airway Bill Number
Value of consignment
Flight number
Expected date and time of arrival
Name of arriving airport

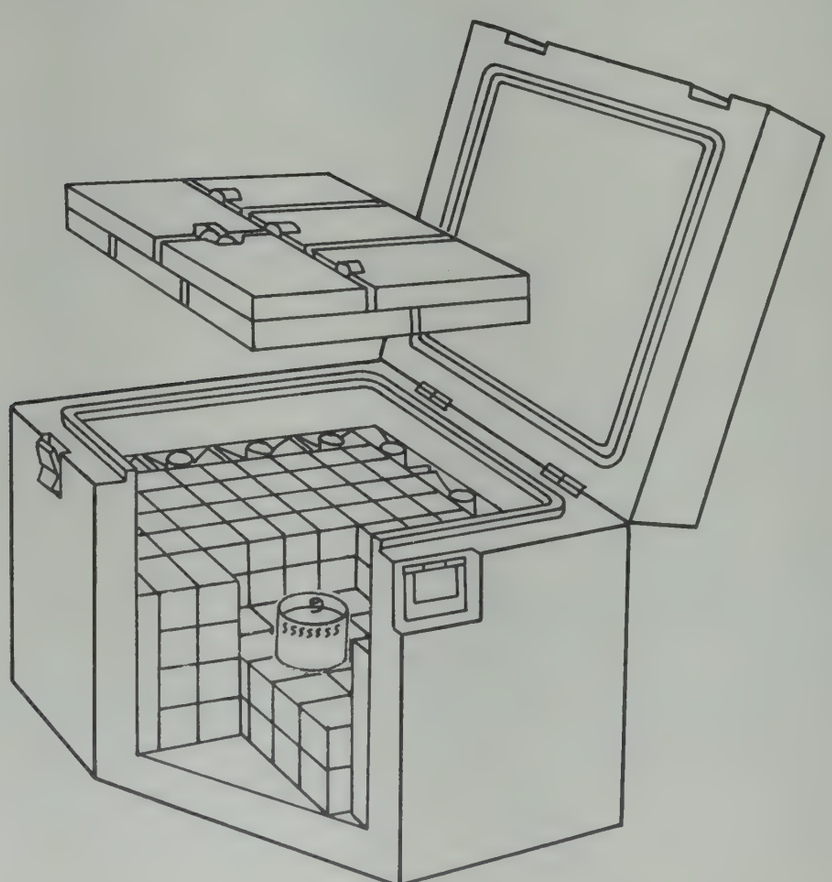
Some test laboratories also test other items of equipment, such as: thermometers, refrigerators, freezers, ice packs and voltage regulators. They use standard WHO tests.

Carrying out your own tests

If you decide to test your cold box yourself, use the following method. It is simpler but less exact. However, it gives you enough information to decide if your cold box is suitable.

Cold life

1. Fill the cold box with the correct number of COMPLETELY frozen ice packs, a full load of expired vaccine or empty vials and a small recording thermometer. Make sure the thermometer will work for longer than the designed cold life. If you do not have any expired vaccine, use anything that fills the space, to keep ice packs in their proper place. If you use empty containers, it is like carrying only freeze dried vaccine such as BCG and Measles. This then reproduces the worst situation.
The recording thermometer should be as near the centre of the box as possible (see Annex V).



2. Choose a very hot place to put the cold box. Find somewhere that gives as high a temperature as you get in your country. The place should be out of the sun, but have as constantly high a temperature as possible. For example, inside a vehicle parked in the shade; in the compressor room of a large cold store. You could also arrange to heat a small room with an electric heater, if constant electricity is available.

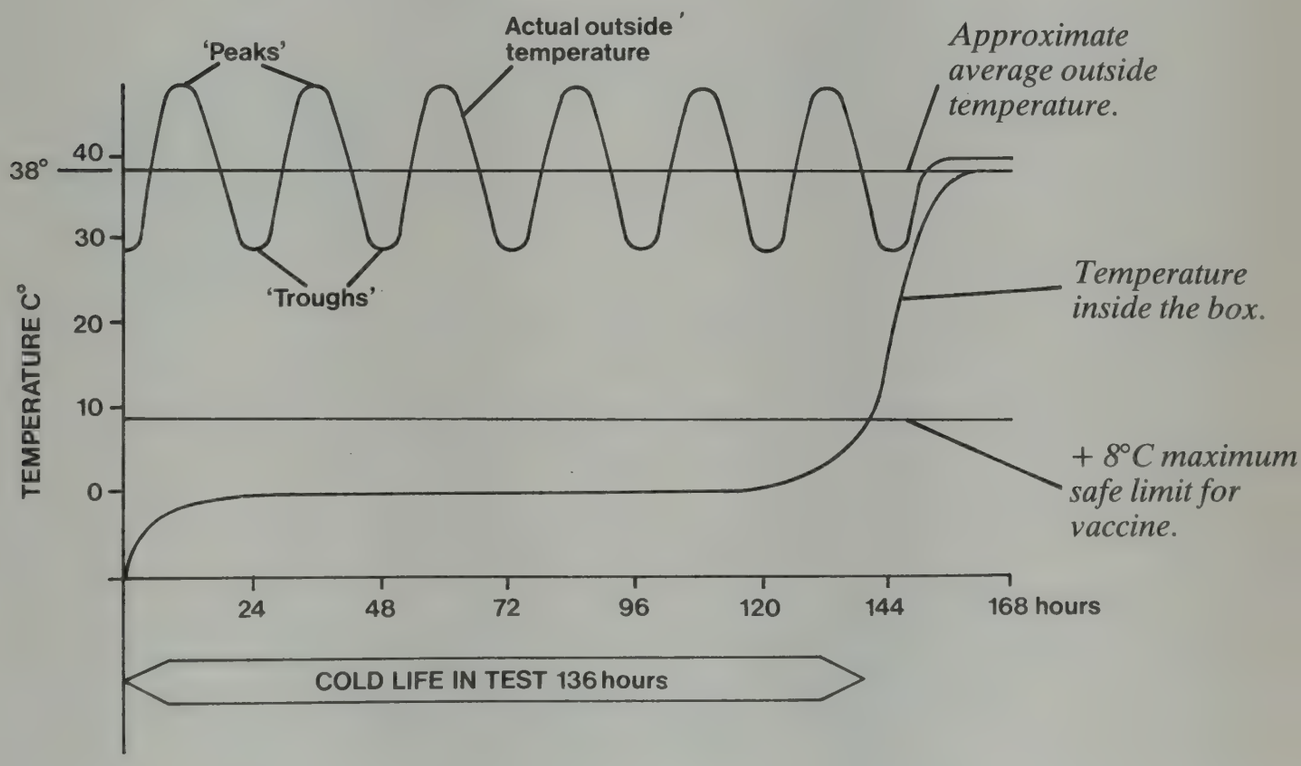
3. Make sure that the lid is firmly shut. Do not open it again until the end of the test. Take a second recording thermometer which also works for a longer period than the cold life of the box. Keep this thermometer outside the cold box to record the ambient temperature.

4. After a period, say 24 hours longer than the designed cold life of the box, open the box and check the thermometer inside. You will probably find that it is near the ambient temperature. If you find it is still in the safe level below +8°C, close the box and leave it another 24 hours. When it has finally reached the ambient temperature remove the discs from both thermometers. Then draw two graphs onto a single piece of paper as follows:

Example of temperature graphs.

From this work out the:–

Average ambient temperature
The cold life of the box



To find the average temperature, draw a line through the graph to balance the 'peaks' and 'troughs'. Then read off the average temperature on the left hand side.
To find the cold life during the test. From the bottom line read the number of hours between closing the box and the moment when the temperature rises above +8°C.

5. You now know the cold life at the average temperature of your test period. To compare this with information on other cold boxes, find the cold life at 32°C and 43°C. To do this use the following tables.

Find:

- the nearest average outside temperature of your test on the left hand side (38°C) and
- the figure nearest your measured cold life in hours on the bottom line (140 hours). Where the 38°C row meets the 140 hours row, there is a figure 166. This is the cold life in hours at 32°C. The second table shows the cold life at 43°C which is 122 hours.

1.

46	28	57	86	115	143	172	201	230	258	287	316	345	373	402
42	27	55	82	110	137	165	192	220	247	275	302	330	357	385
42	26	52	78	105	131	157	183	210	236	262	288	315	341	367
40	25	50	75	100	125	150	175	200	225	250	275	300	325	350
38	23	47	71	95	118	142	166	190	213	237	261	285	308	332
36	22	45	67	90	112	135	157	180	202	225	247	270	292	315
34	21	42	63	85	106	127	148	170	191	212	233	255	276	297
32	20	40	60	80	100	120	140	160	180	200	220	240	260	280
30	18	37	56	75	93	112	131	150	168	187	206	225	243	262
28	17	35	52	70	87	105	122	140	151	175	192	210	227	245
26	16	32	48	65	81	97	113	130	146	162	178	195	211	227
—	20	40	60	80	100	120	140	160	180	200	220	240	260	280

Average temperature °C ➡

⬆

Measured cold life in hours at 32° ambient

2.

46	20	42	63	85	105	127	148	170	190	212	233	255	276	297
44	19	40	60	81	101	122	142	162	182	203	223	244	264	284
42	19	38	57	77	96	116	135	155	174	193	213	233	252	271
40	18	37	55	74	92	111	129	148	166	185	203	222	240	259
38	17	34	52	70	87	105	122	140	157	175	193	210	227	245
36	16	33	49	66	82	99	116	133	149	166	182	199	216	233
34	15	31	46	62	78	93	109	125	141	156	172	188	204	219
32	14	29	40	59	74	88	103	118	133	148	162	177	192	207
30	13	27	41	55	68	82	96	111	124	138	152	166	179	193
28	12	25	38	51	64	77	90	103	116	129	142	155	168	181
26	11	23	35	48	59	71	83	96	108	119	131	144	156	168
—	20	40	60	80	100	120	140	160	180	200	220	240	260	280

Average temperature °C ➡

⬆

Measured cold life in hours at 43° ambient

Durability

○ Drop test

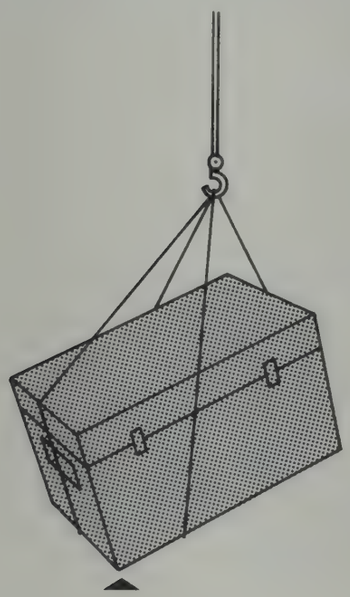
These tests help you decide if the durability of your prototype is good enough. If you wish to make a comparison between your test and those carried out in test laboratories:

1. Completely fill the cold box with ice packs. Each ice pack should be ⅓ full of water. They do not need to be frozen.

2. Close the cold box and secure the catches as they would normally be secured.

3. You are now ready to drop the box onto a solid concrete or stone floor from a height of 1 metre. Measure this height from the lowest point of the box on each drop.

You can hold a small box or carrier by hand before dropping. For a large box it is easier to use a sling on a rope or hoist.



1 metre.

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4. Now drop the box 26 times in the following order:

Face	**Edges**
1. Top	**7.** Front top
2. Bottom	**8.** Back top
3. Front	**9.** Left side top
4. Back	**10.** Right side top
5. Left side	
6. Right side	

11. Front bottom
12. Back bottom
13. Left side bottom
14. Right side bottom
15. Front left side
16. Front right side
17. Back left side
18. Back right side

Corners

19. Front top left
20. Front top right
21. Back top left
22. Back top right
23. Front bottom left
24. Front bottom right
25. Back bottom left
26. Back bottom right

After each drop note the damage. After all the drops, work out the damage on a scale as follows:–

○ Damage to cold box

1. Heavy damage i.e. beyond repair
2. Damage which you can mend
3. Surface damage i.e. insulation undamaged
4. Marked – scratches no cracks
5. Unmarked

○ Damage to fittings

1. hinges and/or catches broken or pulled off
2. undone hinges and/or catches
3. hinges and catches work satisfactorily.

If during the test a part of the load falls out of the box, stop the test. If failure of hinges or catches causes this, reload the box. Fasten the lid and continue the test. This is a very hard test especially for a large cold box. But remember your cold box may have to stand up to some very rough treatment.

Leakage

A poor lid seal usually shortens the cold life of your box very quickly. The easiest way to test a lid seal is to put some water in the box. Then turn it upside down. If any water comes out, the seal is not working. Change it or have it re-designed. It may also mean that the lid is twisted.
This completes the testing of your cold box. If you have followed the methods exactly you can compare your cold box with those of other manufacturers.

Test in use

You may only see some faults after some use. So check now and again with the people who use your cold box to see if they have any comments. After a year retest the cold life of a small sample of the boxes. If it has changed this is probably due to bad sealing of the insulation. Check all the joints on these boxes and also the lid seals. If you find there is damage to the lid seals, change them for new ones. If joints are damaged you must reseal them.

Finally make sure that the people using these cold boxes know how to look after them. This includes:

- Checking and cleaning the lid seal
- Checking and adjusting the catches and hinges
- Mending cracks
- Not sitting or standing on the cold box
- Keeping it clean, dry and out of the sun
- Mending or replacing leaking ice packs

ANNEX I

List of technical words

Ambient temperature	The temperature of the surrounding air normally quoted in relation to temperature inside a cold box.
Capacity	The space available in a cold box.
Centre of gravity	The point in an object about which its weight is evenly balanced.
Cold life	The length of time the temperature inside a cold box remains below 8C, when the outside temperature is 43°C. This is normally in hours.
Durability	The ability of a material to resist any type of damage.
Freezing capacity	The ability of a refrigerator or a freezer to make ice. It is usually described in kilograms of ice per 24 hours.
Glass fibre	Thin threads of glass used to strengthen plastic.
Heat bridge	A connection between inside and outside which allows heat to pass through insulation more rapidly than the insulation.
Ice packs	Plastic containers filled with water which you can freeze. They are usually rectangular with a cpacity of 0.25–1.0 litres.
Insulation	A material which prevents the transfer of heat.
Net volume	The space for storage of vaccine in a cold box after you put in the ice packs.
Polyester resin	The plastic component used in the making of G.R.P.
Prototype	A model made to test a design before mass production begins.
Thermal conductivity	The ability of a material to allow heat to pass through it.
Thermo plastic	A plastic material which can be melted by heat and rehardens without any damage.
Vacuum impregnation	A factory method of making sure wood is fully protected against termites.

ANNEX II
List of cold boxes and ice packs

Vaccine Carrier Model II

Vaccine capacity:	0.35 litres	Beijing II Electro-Mechanical Mfg. Ding-Fu-Zhuang East Suburb Beijing People's Republic of China
External dimensions:*	26 × 19 × 19 cm	
Cold life (43°C):	28 hours	
Weight fully loaded:	2.1 kg	
Durability:**	3	
No. of ice packs:	2	
Kg of ice packs:	0.8	
Price (US$):	9	

Vaccine Carrier Model I

Vaccine capacity:	1.5 litres	Beijing II Electro-Mechanical Mfg. Ding-Fu-Zhuang East Suburb Beijing People's Republic of China
External dimensions*:	25 × 26 × 26 cm	
Cold life (43°C):	56 hours	
Weight fully loaded:	3.7 kg	
Durability:**	2	
No. of ice packs:	4	
Kg of ice packs:	1.6	
Price (US$):	10	

EPI/PF/1.5

Vaccine capacity:	1.5 litres	Polyfoam Chemical Corporation 32 Miller Street San Francisco del Monte QUEZON CITY Philippines
External dimensions:*	26 × 29 × 28 cm	
Cold life (43°C):	45 hours	
Weight fully loaded:	4.0 kg	
Durability:**	3	
No. of ice packs:	4 I***	UNIPAC 1185075
Kg of ice packs:	1.6	
Price (US$):	11	

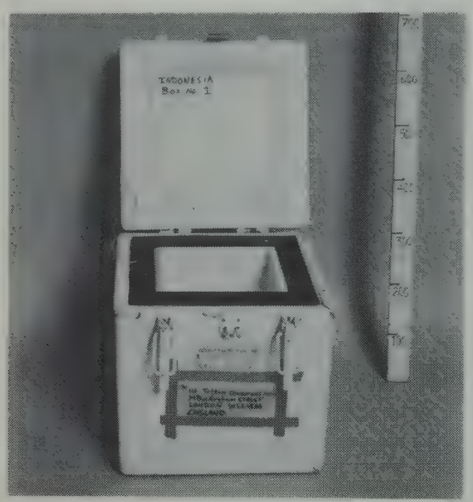
* Dimension = depth × width × height

** 1 = heavy damage
2 = repairable damage
3 = superficial damage
4 = marked
5 = unmarked

*** I = ice packs included in purchase price

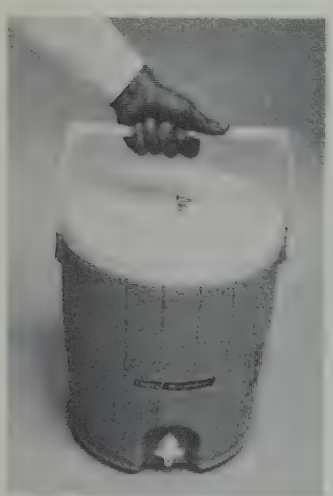
Vaccine Carrier 3504

Vaccine capacity:	1.7 litres	King Seeley Thermos Company Thermos Divison NORWICH CT 06360 USA
External dimensions:*	24 × 24 × 33 cm	
Cold life (43°C):	34 hours	
Weight fully loaded:	4.0 kg	
Durability:**	3	
No. of ice packs:	4 I***	UNIPAC 1185000
Kg of ice packs:	2	
Price (US$):	23	



Type D(1)

Vaccine capacity:	2.9 litres	C.V. Straightway Trading Corp. J1. Tebet Barat Dalam 91 JAKARTA – SELATAN Indonesia
External dimensions:*	36 × 36 × 38 cm	
Cold life (43°C):	58 hours	
Weight fully loaded:	12.0 kg	
Durability:**	Satisfactory	
No. of ice packs:	6	
Kg of ice packs:	?	
Price (US$):	96	



Roundabout Cooler, Model 5530

Vaccine capacity:	4 litres	Coleman International Div. 211 East 37th Street North Wichita Kansas 67219 USA
External dimensions:*	32 × 38 cm	
Cold life (43°C):	11 hours	
Weight fully loaded:	7 kg	
Durability:**	3	
No. of ice packs:	6	
Kg of ice packs:	3	
Price (US$):	17	

Gnat VI

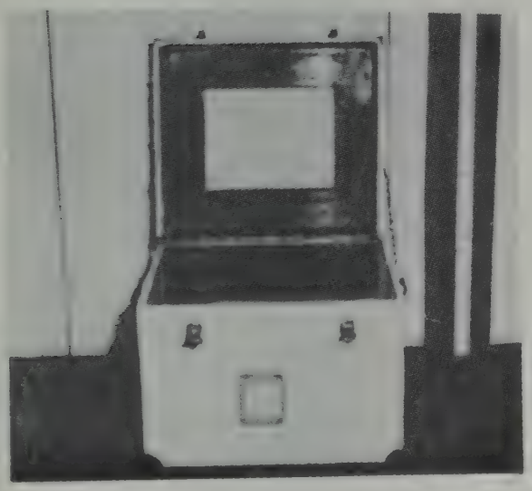
Vaccine capacity:	6.8 litres
External dimensions:*	57 × 50 × 49 cm
Cold life (43°C):	77 hours
Weight fully loaded:	25.7 kg
Durability:**	3
No. of ice packs:	19
Kg of ice packs:	7.8
Price (US$):	150

Attn. P. K. Verma
Gnat Agencies
C/2 Paschimi Marg
Main Market
Vasant Vihar
NEW DELHI 110057
India

Type C(2)

Vaccine capacity:	7.5 litres
External dimensions:*	51 × 51 × 52 cm
Cold life (43°C):	67 hours
Weight fully loaded:	23.0 kg
Durability:**	2
No. of ice packs:	7
Kg of ice packs:	6.3
Price (US$):	157

C.V. Straightway Trading Corp.
Jl. Tebet Barat Dalam 91
JAKARTA – SELATAN
Indonesia



Gnat I

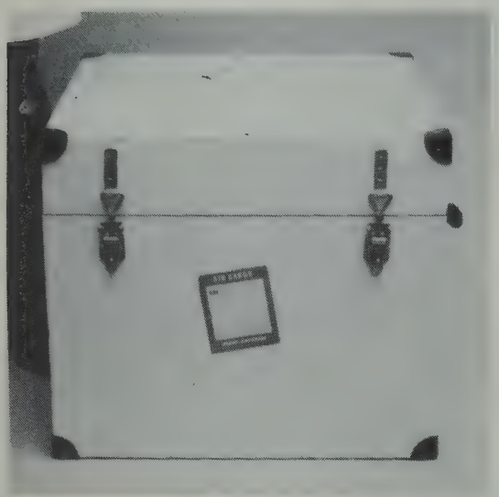
Vaccine capacity:	8 litres
External dimensions:*	56 × 50 × 49 cm
Cold life (43°C):	83 hours
Weight fully loaded:	28.0 kg
Durability:**	1
No. of ice packs:	12
Kg of ice packs:	8
Price (US$):	105

Attn. P. K. Verma
Gnat Agencies
C/2 Paschimi Marg
Main Market
Vasant Vihar
NEW DELHI 110057
India

Cold Box 30 Litres

Vaccine capacity:	10 litres
External dimensions:*	56 × 61 × 50 cm
Cold life (43°C):	134 hours
Weight fully loaded:	32.9 kg
Durability:**	3
No. of ice packs:	24
Kg of ice packs:	10
Price (US$):	140

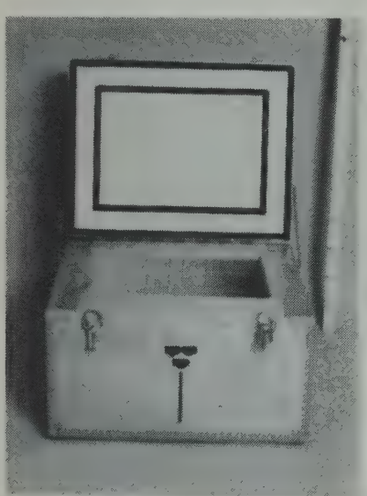
Zamrock Fiberglass Corporation Ltd.
15-C-1 Gulberg III
P.O. Box 3145
Lahore – II
Pakistan



Gnat III

Vaccine capacity:	10 litres
External dimensions:*	56 × 50 × 49 cm
Cold life (43°C):	74 hours
Weight fully loaded:	33 kg
Durability:**	1
No. of ice packs:	13
Kg of ice packs:	9
Price (US$):	120

Attn. P. K. Verma
Gnat Agencies
C/2 Paschimi Marg
Main Market
Vasant Vihar
NEW DELHI 110057
India



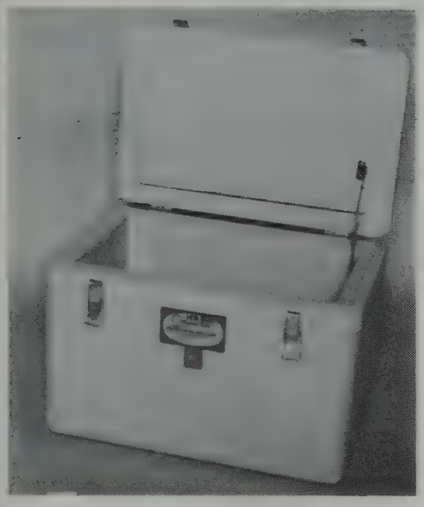
Thermosafe Model 390

Vaccine capacity:	18.7 litres
External dimensions:*	37 × 53 × 56 cm
Cold life (43°C):	58 hours
Weight fully loaded:	23 kg
Durability:**	3
No. of ice packs:	25
Kg of ice packs:	10
Price (US$):	118

Polyfoam Packers Corporation
2320 S. Foster Avenue
WHEELING
Illinois 60090
USA

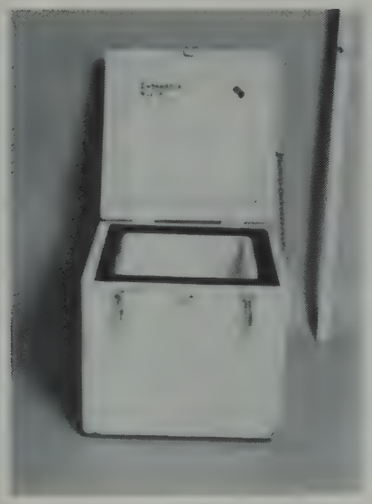
Type 5

Vaccine capacity:	20 litres	Lembaga Afiliasi Penalitian Industri Institut Technologi Bandung Jalan Ganesha 10 BANDUNG Indonesia
External dimensions:*	46 × 49 × 47 cm	
Cold life (43°C):	26 hours	
Weight fully loaded:	29.0 kg	
Durability:**	1	
No. of ice packs:	14	
Kg of ice packs:	11.5	
Price (US$):	75	



NBL2/A

Vaccine capacity:	21.0 litres	The National Bacteriological Laboratories S-10521 STOCKHOLM Sweden
External dimensions:*	51 × 58 × 75 cm	
Cold life (43°C):	132 hours	
Weight fully loaded:	50.0 kg	
Durability:**	3	
No. of ice packs:	22 I***	UNIPAC 1185050
Kg of ice packs:	14	
Price (US$):	264	Minimum Order: 100



Type B(3)

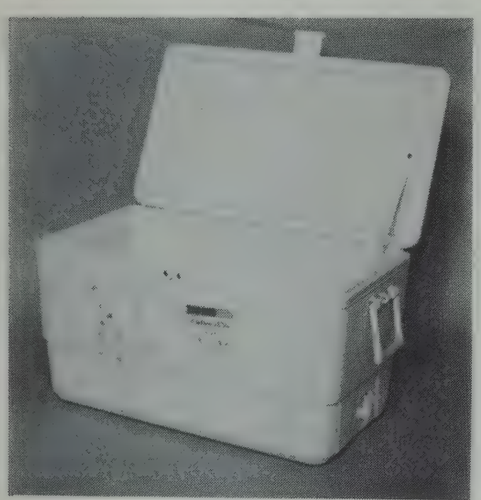
Vaccine capacity:	21.0 litres	C.V. Straightway Trading Corp. Jl. Tebet Barat Dalam JAKARTA – SELATAN Indonesia
External dimensions:*	58 × 58 × 59 cm	
Cold life (43°C):	53 hours	
Weight fully loaded:	39.0 kg	
Durability:**	2	
No. of ice packs:	20	
Kg of ice packs:	13	
Price (US$):	164	

Electrolux RCW25

Vaccine capacity:	22 litres	Electrolux AB Internal Division S-10545 STOCKHOLM Sweden
External dimensions:*	71 × 56 × 49 cm	
Cold life (43°C):	190 hours	
Weight fully loaded:	42 kg	
Durability:**	5	
No. of ice packs:	24 I***	UNIPAC 1185052
Kg of ice packs:	15	
Price (US$):	202–187 depending on quantity	

Snowlite, Model 5243B720

Vaccine capacity:	23.5 litres	Coleman International Division 2111 East 37th Street North WICHITA Kansas 67219 USA
External dimensions:*	56 × 34 × 34 cm	
Cold life (43°C):	17 hours	
Weight fully loaded:	13.0 kg	
Durability:**	2	
No. of ice packs:	12	
Kg of ice packs:	4.9	
Price (US$):	44	



Igloo 68-Quart

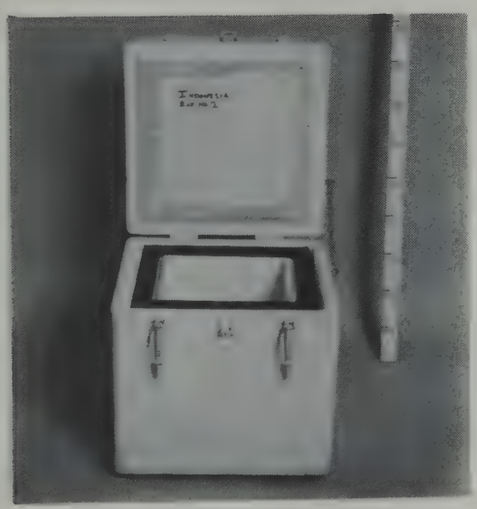
Vaccine capacity:	26.9 litres	Igloo Corporation P.O. Box 19322 HOUSTON Texas 77024 USA
External dimensions:*	74 × 41 × 38 cm	
Cold life (43°C):	69 hours	
Weight fully loaded:	35 kg	
Durability:**	2	
No. of ice packs:	28	
Kg of ice packs:	18.4	
Price (US$):	39	

Type 20L

Vaccine capacity:	31.0 litres	Savopak Oy P.O. 78201 VARKAUS 20 Finland
External dimensions:*	83 × 62 × 50 cm	
Cold life (43°C):	140 hours	
Weight fully loaded:	51.0 kg	
Durability:**	3	
No. of ice packs:	19	UNIPAC 1185055
Kg of ice packs:	19	
Price (US$):	230	

Type (6)

Vaccine capacity:	33 litres	Lembaga Afiliasi Penalitian Industri Institut Technologi Bandung Jalan Ganesha 10 BANDUNG Indonesia
External dimensions:*	61 × 65 × 63 cm	
Cold life (43°C):	104 hours	
Weight fully loaded:	50.0 kg	
Durability:**	1	
No. of ice packs:	26	
Kg of ice packs:	17.4	
Price (US$):	110	



Type A(4)

Vaccine capacity:	33.4 litres	C.V. Straightway Trading Corp. Jl. Tebet Barat Dalam 91 JAKARTA – SELATAN Indonesia
External dimensions:*	62 × 64 × 62 cm	
Cold life (43°C):	89 hours	
Weight fully loaded:	48.0 kg	
Durability:**	2	
No. of ice packs:	26	
Kg of ice packs:	16.6	
Price (US$):	179	

Vaccine Packaging 49 Litre

Vaccine capacity:	35 litres	Savopak Oy P.O. Box 103 SF 78201 VARKAUS 20 Finland
External dimensions:*	53 × 53 × 55 cm	
Cold life (43°C):	180 hours	
Weight fully loaded:	31.7 kg	
Durability:**	NOT TESTED	
No. of ice packs:	40	
Kg of ice packs:	16.5	
Price (US$):	35 F.O.B.	

ANNEX III Suitable glues

Plastics to be glued		Glue										
		Elastomers:	Acrylonitril Butadiene	Polychloroprene	Polyurethane	**Thermoplastic:**	Cyanoacrylate	**Thermosets**	Epoxy resins	Phenolic nitrile	Polyester (unsaturated)
Thermoplastics											
– Polyvinylchloride	(PVC)		X	X	X				X		
– Polyethylene	(PE)								X	X	
– Polystyrene	(PS)				X		X				
– Acrylonitril Butadiene Styrene	(ABS)				X		X				
Thermosets											
– Polyester									X		X

ANNEX IV Insulation formula

Formula used to calculate the cold life graphs on pages 10 and 12.
You can use the two formulae to work out quickly the cold life of a vaccine cold box.

$$T32 = \frac{Mw \times 3.62 + Mvac \times 0.13 \text{ (Hours)}}{\frac{\lambda}{S} \times \sqrt{Ae \times Ai}}$$

$$T43 = \frac{Mw \times 2.68 + Mvac \times 0.13 \text{ (Hours)}}{\frac{\lambda}{S} \times \sqrt{Ae \times Ai}}$$

T32 = Cold life in hours with an outside temperature of + 32°C

T43 = Cold life in hours with an outside temperature of + 43°C

Mw = Mass of water (kg cold packs)

Mvac = Mass of vaccine (kg)

λ = Heat conductivity of insulation (w/m°C)

S = Thickness of insulation (m)

Ae = External surface area of the box (m^2)

Ai = Internal surface area of the box (m^2)

Typical values of λ

Values	*w/m°C*
Cork	0.050
Glass fibre	0.033
Polystyrene foam	0.037
Polyurethane foam	0.024

ANNEX V Recording thermometer*

Thermometers, thermorecorders and indicators for monitoring vaccine storage
Thermomètres, thermomètres enregistreurs et indicateurs pour le contrôle du stockage des vaccins
Termómetros, termorregistradores e indicadores para controlar almacenamiento de vacunas

Ref.: **E6**/9

Date: May 1983
Date: Mai 1983
Fecha: Mayo 1983

Product Information Sheet
Fiche Signalétique d'Article
Hoja de Información sobre Productos

World Health Organization (EPI)/UNICEF
Organisation mondiale de la Santé (PEV)/FISE
Organización Mundial de la Salud (PAI)/UNICEF

1. Purchasing description:
A spécifier à la commande:
Descripción del artículo:

7 day Portable Recording Thermometer (Lexan Cover) Model 615p

2. Company name and address:
Nom et adresse du fabricant:
Nombre y dirección de la compañia:

Pacific Transducer Corporation Tel: (213) 478-1134
2301 Federal Avenue
Los Angeles, CA 90064
U.S.A.

3. Type of operation Mode de fonctionnement Mecanismo de operación	Bi-metallic sensing element Elément sonde bimétallique Elemento sensor bimetálico
4. Temperature range/accuracy Gamme de températures/précision Intervalo de temperatura/exactitud	$-40^{\circ}C \rightarrow +70^{\circ}C/\pm 2\%$
5. Safe-range marking Etalonnage pour le stockage des vaccins Marca de control de almacenamiento de vacunas	Yes Oui Si
6. Number of pens/sensors Nombre de styles/éléments sensibles Número de agujas/sensores	1
7. Length of capillaries Longueur des capillaires Longitud de los capilares	NA
8. Number of days per cycle (recorders) Cycle, en nombre de jours (enregistreurs) Ciclo en número de días (registros)	7
9. Power source (recorders) Source d'énergie (enregistreurs) Tipo de energía (registros)	Spring-wound Remonté avec un ressort Mecanismo de cuerda
10. Max/min indicator Aiguille max/min Indicador de max/min	NA
11. Number of alarm contacts Nombre de contacts d'alarme Número de contactos de alarma	0

12. Overscale protection limit Limite de protection (dépassement d'échelle) Límite de protección por encima de la escala	NA
13. Casing material Revêtement Material de envoltura	Black anodized aluminium Aluminium noir anodisé Aluminio anodizado negro
14. Face material Matériau de la partie antérieure Material de la parte anterior	Plastic Plastique Plastico
15. Humidity/dust protection Protection contre l'humidité et la poussière Protección contra la humedad/polvo	No airtight seal Pas d'étanchéité à l'air No hay cierre hermético
16. Dimensions Dimensions Dimensiones	Diameter 100 x 82 mm
17. Weight Poids Peso	0,4 kg
18. Supply delay Délai de livraison Demora de entrega	1 weeks semaines semanas
19. Cost in US dollars Prix en dollars US Precio en US dólares	$147 FOB

Comments: Also available in Fahrenheit/Disponible également en Fahrenheit/Disponible también en Fahrenheit (615pF)
Observations: Extra charts/Papiers enregistreurs supplémentaires/Tarjetas de repuesto: 100 = $7 - 1 000 = $55
Comentarios: Dry stylus operation/Inscription avec une pointe sèche/Funcionamiento con estilo seco

*Reproduced courtesy of WHO/EPI/UNICEF

The Appropriate Health Resources and Technologies Action Group Ltd.

AHRTAG is concerned with the promotion of equipment and techniques for health care at community level. It does this through publications and an information service.

Special areas of interest include:

- the cold chain
- dental health
- disability prevention and rehabilitation
- diarrhoeal diseases

Since it began in 1977, AHRTAG has been in touch with overseas groups with similar interests and is part of an informal world network linking people committed to the development of primary health care.

Publications:

- How to look after a refrigerator'
  by Jonathan Elford, gives step-by-step instructions for the care and maintenance of kerosene, gas and electric refrigerators. Also available in Spanish and Turkish, 58 pp (1980)
- 'Low cost aids'
  by Don Caston & Joan Thompson, shows a wide range of aids for disabled children, 53 pp (1982)
- 'Low cost physiotherapy aids'
  by Don Caston & Joan Thompson, 45 pp (1982)
- 'How to look after a health centre store'
  by Anthony Battersby, includes all aspects of storekeeping including how to order supplies and how to look after and dispense them, 72 pp (1983)

For details of prices and postage write to TALC, PO Box 49, St. Albans, Herts AL1 4AX, United kingdom.

Free publications:

- 'Diarrhoea Dialogue' – a quarterly newsletter on all aspects of diarrhoeal disease control. Also available in French and Spanish.
- 'How to make hand grips' – a poster showing ways in which clay, plaster and epoxy resin putty can be used to make hand grips to allow disabled people to hold tools, spoons and brushes, etc. (1981)
- 'The AHRTAG baby length measurer' – free working drawing for a simple, lightweight, baby length measurer which can be made from wood and taken apart for easy carrying (1982)
- 'How to make an illuminator' – a free leaflet of a simple design for an illuminator which can be used with an oil or candle lamp, battery power, mains electricity or even sunlight (1982)
- Dental health newsletter – bi-annual newsletter promoting dental health care
- Aids for living – bi-annual newsletter on aids for disabled people

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